THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. III.

No. III.—MARCH, 1896.

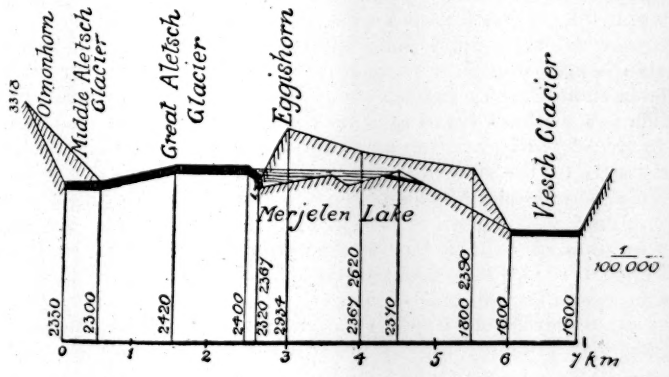
ORIGINAL ARTICLES.

I.—The Merjelen Lake (Aletsch Glacier).

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.C.S.

(PLATE VI.)

THE Merjelen or Maerjalen Lake, situated at an altitude of 2367 metres (7750 ft.) above sea-level at the western flank of the Great Aletsch glacier, belongs to the class of glacier lakes which are found in depressions or valleys barred by glaciers whose direction of flow is more or less at right angles to the same. Like the majority of glacier lakes, it has the shape of an irregular triangle, the length being about 1·5 kilometre (nearly a mile), its greatest



width 0·5 kilometre (550 yards), and its mean depth 28 metres (92 ft.). Hence its superficial area amounts to 375,000 square metres (438,000 square yards), and its volume at high-water level to about 10 million cubic metres or tons.

As is shown in the section reduced by the writer from the Swiss Contour Map, the lake is shut in by the Eggishorn to the south and by Strahlhorn to the north, while at its western or broader end it is barred by an ice-wall 500 metres (550 yards) in

length and about 50 metres (164 ft.)[1] in depth, formed by the Aletsch glacier. The cross valley or depression in the gneiss formation between the Aletsch and Viesch glaciers was, in times of more extensive glaciation, evidently filled by an offshoot of the former glacier into the Viesch valley, although the fine mud which covers the bottom of the lake is not, as has been averred, old moraine,[2] but simply deposit of the particles held in suspension by the lake. Under the glacial conditions of the present day, the Aletsch glacier is unable to invade and fill the lake basin, the more so as the lake is, in addition to glacier water, fed by spring water, and notably from a small tarn on the Merjelen Alp about 760 ft. above the lake-level, so that the water in the lake is kept in motion, and permanent congelation is thus prevented. Indeed, the melting power of the lake water is evidenced by the fact that, although the surface of the Aletsch glacier slopes gently into the lake, the slope is, below the water's edge, undermined and melted down to a vertical wall or cliff. The glacier thus acts as a retaining wall to the lake, while the latter retains, that is, prevents the intrusion of, the glacier.

The natural outlet of the lake is to the west, through the Aletsch glacier; but when the lake exceeds a certain level, it has at its eastern or narrow end an additional outflow to the Viesch glacier, over a low divide or saddle which, at ordinary level, separates it from the drainage area of that glacier. The lake thus possesses the peculiar feature of having two outlets in opposite directions.

In addition to its contiguity to the Aletsch glacier, and to the intensely, almost unique, greenish-blue colour of its water,[3] the Merjelen lake possesses, as is well known, the further peculiarity, not only of sudden fluctuations of level, but of emptying itself at irregular intervals, and sometimes within the space of eight or twelve hours, through a temporary passage in the glacier wall, the phenomenon being on certain occasions accompanied by a great noise, which is sometimes heard at a distance of no less than six miles, and is produced partly by the overhanging roof of the glacier falling in and partly by the rush of water through the glacier.

This remarkable Alpine phenomenon recurred during the night from Monday to Tuesday, 23rd to 24th September last. Already, in the autumn of 1894, a partial emptying had taken place, the lake being then reduced to about one-third of its volume at high water. As is usual in the case of partial emptying, there remained two lakelets or tarns—an upper, smaller and shallow one, and a lower, larger one, deepening rapidly towards the glacier end, the two basins being divided by a path which leads to Concordiahütte and is submerged when the lake is at high level. During the hot and dry summer of 1895 the lower basin rose again; at the end of August

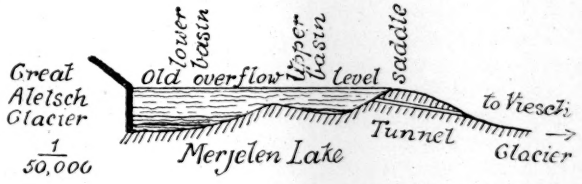
[1] The exact depth deduced from the Swiss Contour Map is 47 metres (154 ft.), while that measured by Prof. Ramsay in 1858 was 157 ft.

[2] Ph. Gosset, Jahrbuch S.A.C. 1887–8.

[3] This colour appears to correspond approximately to shade v of Prof. F. A. Forel's scale of eleven shades of lake waters.—F. A. Forel, "Le Léman," vol. ii, p. 464. Lausanne, 1895.

the two basins were again united; and by the 20th of September the lake had risen further 2·5 metres (8 feet), when along the glacier wall there appeared a distinctly marked water-line, which afforded unmistakable proof that the lake-level was again beginning to drop. On that day it fell 10 centim. (4 inches); on September 21st, 30 centim. (12 inches); on the 22nd the fall was 2 metres (6·6 feet); on the 23rd the total fall reached 6 metres (20 feet); and during the night the lake emptied itself so completely that on the following morning the glacier wall was exposed to view to its full depth of about 50 metres (165 feet), and exhibited a large number of ice-caves and perpendicular fluted fissures, while the bottom of the lake was strewed with blocks of ice which, as is characteristic of the Merjelen lake, had been floating on its surface, or had recently fallen, and were still falling, from the undermined, and therefore overhanging, roof of the glacier projecting into the lake. The spectacle of the stranded and still falling masses of ice, but more especially that of the ice-cliff exposed in all its freshness, is one of exceeding grandeur, although this freshness completely disappears after a few days owing to the action of the air.

On comparing this occurrence with the one of July 19th, 1878—the only one of which detailed record exists[1]—the writer finds that on the latter occasion the lake-level began to drop in the morning of July 18th, the drop being only one metre (about three feet) during



that day, further 3 metres (10 feet) during the night, and 40 metres (130 feet), or practically to the bottom, during the day of the 19th July. On both occasions, the phenomenon, therefore, occurred under very similar conditions, the only difference being that in 1878 the initial drop took about twenty-four, and in 1895 about 48 hours, whilst the time within which the lake emptied itself did, in both cases, not exceed twelve hours. The bulk of the water thus abstracted from the lake, after finding its way through fissures in the glacier, discharges by the Aletsch glacier stream called the Massa torrent, into the Rhone near Naters, about 2·5 kilometres (1·5 mile) above Brieg. The occurrence of 1878 caused the Rhone at Brieg to rise about 1·5 metre (5 feet) above its, then fortunately, low level.

[1] A short notice of this occurrence is given by F. v. Salis in the Jahrbuch of the Swiss Alpine Club, 1878 to 1879. Prof. T. G. Bonney ("Nature," 1867, xxxvi, p. 612) in August, 1858, also saw the lake full one day and empty the next, the emptying having taken place during the night. On the other hand, in 1890, according to Prince Ronald Bonaparte, the emptying of the lake did not take place till five days after the initial fall ("Archives de Genive," xxiv, 1890, p. 401).

The emptying of the Merjelen lake recurs at irregular, and not at all, as is popularly assumed, at regular intervals.[1] It has been explained by the existence of a tunnel in the glacier,[2] which is supposed to widen, narrow, or close entirely, according as the glacier shifts its position, the total emptying, the partial emptying, or the rise to overflow level of the lake being the result. But this explanation is far from satisfactory. During a period of growth of the glacier, the supposed tunnel would move downward at the rate of about 50 metres per annum, or half a foot per day (viz. at about half the speed of the glacier at its axis); hence, in ten years it would travel the whole length of the bar of 500 metres, and the supposed tunnel would then become inoperative so far as the lake is concerned.

The theory of this mysterious tunnel, whose connection with the stream flowing at the bottom of the glacier has, moreover, never been explained, may therefore be discarded; and, in my view, the phenomenon of the lake rising to its maximum level is due essentially to meteorological causes, while the emptying is produced by mechanical agency. In other terms, the rise to the maximum level is due to the rate of ablation or melting of the ice at the glacier wall being, at certain periods, *e.g.* during a hot and dry summer or during the prevalence of hot southerly winds (Foehn), largely in excess of the ordinary outflow through small fissures in the glacier wall; while the emptying of the lake in the space of ten or twelve hours is due to the largely increased pressure of the volume of water against the glacier wall,[3] whose porous condition, produced by the process of ablation, facilitates the formation of large fissures, through which the efflux of the water takes place. The fact of the level of the lake at first falling comparatively slowly, say about six feet in twelve hours, and then rapidly, or about 160 feet in the same period, is easily explained by the gradual yielding of the ice to the pressure of the water, until the rent or orifice enlarges and the rate of efflux is thereby accelerated.

The drainage area of the lake is about 3 square kilometres, or 1·15 square mile, which, at an annual rainfall of 3 metres (10 feet), and allowing 45 per cent. for absorption and evaporation, yields about 5 million cubic metres or tons per annum. The lake may therefore be said to contain its normal volume when it is about half full. To keep it at this normal level, the requisite outflow is only 0·04 cubic metre, or 1·4 cubic foot, per second, and this, at a mean head of

[1] The lake is said to have emptied itself formerly every seven years, latterly every three years.

[2] Ph. Gosset, Jahrbuch S.A.C. 1887 and 1888, p. 350.

[3] The pressure of a head of water of 50 metres (164 feet) is equal to five atmospheres or 73 lbs. per square inch; and the pressure of the whole volume of the lake on the porous glacier wall is no less than $\frac{10,000,000}{500 \times 50} = 400$ tons per square metre, or 37 tons per square foot, viz. five times the pressure allowed for the walls of large reservoirs.

water of 14 metres (46 feet), requires an orifice of only 23 square centimetres,[1] or 3·6 square inches, so that a very small fissure in the ice-wall suffices for the ordinary drainage of the lake through the glacier. When the lake, swelled by water derived from the glacier, reaches its maximum level (viz. contains 10 million cubic metres or tons, or double its normal volume), and then empties itself, the discharge of about 1 million cubic metres during the first twelve hours corresponds to 23 cubic metres (805 cubic feet) per second, or, at a mean head of 25 metres (82 feet), to an orifice of 1 square metre (10·7 square feet); and the discharge of 9 million cubic metres in the following twelve hours corresponds to nine times as much—that is, to 208 cubic metres per second, and to an orifice of 9 square metres, or about 100 square feet. The outflow of about 200 cubic metres per second is larger than the average volume of the Rhone at its inflow into the lake of Geneva (150 cubic metres per second); but the pressure, and hence the velocity, of the discharge from the Merjelen lake is, of course, so much greater, that a much smaller sectional area is required. It is thus seen that the fissures or rents through which the lake empties itself are by no means of extraordinary dimensions. The whole process is, in fact, precisely like that of an ordinary reservoir discharging its contents through a rent gradually formed and widening in a saturated dam; in both cases, the discharge takes place at the point of least resistance.

There are no exact data to show how much time the lake requires to refill to its normal level (about half full); but it is evident that this operation is performed very gradually, and chiefly in winter and early spring, when, owing to the stoppage of ablation, the glacier wall becomes again compact, and the lake is fed by increased precipitation in its drainage area. The greater frequency of the partial or complete emptying of the lake within the last twenty years coincides with the ascertained general recession or shrinkage of the Great Aletsch glacier since 1873[2]; and there is, possibly, a relation between the two phenomena, since both are, in the main, the effects of meteorological causes.

Owing to the conflict of evidence, it is extremely difficult to obtain authentic information respecting the partial or complete emptying of the lake and the exact dates of the phenomenon. This much, however, is certain, that a partial emptying produced by the forcing of a passage at a point above the base of the glacier wall is of much more frequent occurrence than a total discharge of the lower basin. Even in the latter case a pool always remains in the upper or shallow basin. Moreover, the mere fact of the lake having

[1] The sectional area is given by the volume divided by the velocity, and the velocity is given by $\sqrt{2gh}$, g being the acceleration due to gravity = 10 (metric), and h the mean head of water.

[2] Like the majority of Alpine glaciers, the Aletsch glacier increased during the first half of this century; its decrease began about 1860, and has become more marked since 1873. In 1893 it receded five metres or seventeen feet, according to Prof. F. A. Forel's "Variations Périodiques des Glaciers des Alpes" for that year.

been seen empty at any time, is *per se* of no value unless it is also shown that it was seen full the day or a few days before; otherwise it may, according to the season, have been empty for months. The following are the years (since 1870) in which the phenomenon has been recorded,[1] the total emptyings in eight to twelve years being marked with an asterisk, while the cases of the lake being seen about half full are omitted, because this, as already shown, is its normal condition. It will be observed that the phenomenon occurs always between June and September, an additional proof that it is essentially due to meteorological causes:—1871. August, 1872. 1873.* July, 1878.* June, 1882. August, 1884. August, 1885. September, 1887.* June, 1889. July, 1890.* July, 1892. September, 1894. September, 1895.*

Until recently, when the lake exceeded its ordinary maximum level before it had forced a passage through the Aletsch glacier, an overflow took place over the low saddle to the east towards the Viesch glacier, about 770 metres or 2540 feet below the level of the lake. In both cases the sudden rise either of the Aletsch or of the Viesch torrent occasionally flooded part of the Rhone valley above Brieg;[2] and it is with the view of eliminating this danger that the outlet of the lake to the Viesch valley has recently been artificially lowered about 7 metres, or 23 feet, by a tunnel driven through the low divide, about 700 yards in length and two square metres (21·4 square feet) in section, which is intended to drain and discharge on the Viesch glacier the overflow as soon as the lake rises about three metres (ten feet) above the level at which the lower and upper basins unite. The overflow of which the lake will thus be relieved is about three million cubic metres, equal to about one-third of its volume at maximum level.

It is, however, evident that although this artificial drain will greatly mitigate, if not altogether prevent, the contingency of damage, a discharge through the Aletsch glacier will always be liable to occur whenever the ice-wall has become sufficiently porous or undermined to yield to the pressure of the water.[3] Thus, while rendered practically harmless, the Merjelen lake will still retain the special feature which makes it unique among the glacier lakes of the Alps.

[1] The data up to 1890 are derived from the lists given by M. Ph. Gosset and by Prof. F. A. Forel (Jahrbuch Swiss Alpine Club, 1887 to 1890, p. 356, and 1890 to 1891, p. 358); those up to 1895 are collected by myself.

[2] Formerly, the cowherd who first arrived in the Rhone valley with the news of the lake having emptied itself (the distance from the lake to Brieg being about nine miles) was rewarded with a pair of new shoes.

[3] This actually happened on the 23rd September last, when the lake had risen to within 50 centimetres (1·6 foot) of the floor of the overflow tunnel, and then, as if to show its contempt for this work of man's hand, emptied itself again through its natural channel, the Aletsch glacier. The committee of inspection which was on its way from Brieg, expecting to see the overflow tunnel in operation, arrived on the 24th September only to find the lake empty.

II.—The Ice-Avalanche on the Gemmi Pass (Switzerland).

By C. S. Du Riche Preller, M.A., Ph.D., M.I.E.E., F.G.S., F.C.S.

IT is a noteworthy fact that, although Alpine glaciers have, during the last few years, not shown any very marked oscillations,[1] the Central Alps have, since the year 1892, been annually visited by a disaster caused, directly or indirectly, by the bursting or falling of a glacier. Thus, in 1892, the Tête Rousse glacier of the Mont Blanc group swept away the Baths of St. Gervais; in 1893, the village of Taesch, between Viess and Zermatt, was devastated by the torrent of the Weingarten glacier, not far from the village of Randa, which

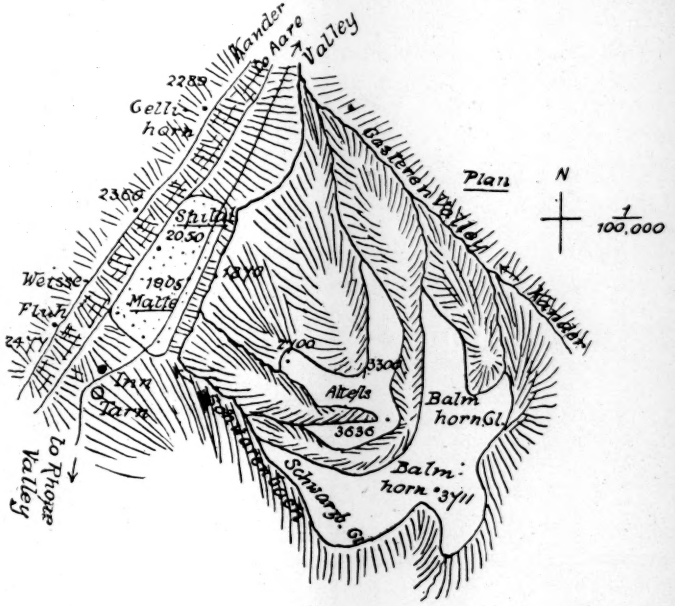


Fig. 1.

was destroyed by a glacier avalanche in the year 1819; again, in 1894, the torrent of the Crête glacier (Grand Combin group, Rhone valley) suddenly poured its flood into the river Dranse, and thereby endangered the town of Martigny; while last year the record was swelled by the avalanche of the Altels glacier on the north side of the Gemmi Pass, in the Bernese Oberland.

The scene of this last catastrophe is at an altitude of about 1950 m. (6400 ft.) above sea-level, nearly midway between Kanderstag and the summit of the Gemmi Pass, familiar to tourists crossing the

[1] Official measurements made in 1893, after a dry and hot summer, showed that out of 28 glaciers in Canton Valais (Rhone valley), 14 had receded 3 to 28 metres, 3 had remained stationary, 10 had advanced 2 to 30 metres, and only one (Zigior glacier, Mont Collon group) had advanced 100 metres, or about 1 ft. per day.

Aare and Rhone divide by the Kander valley and the Baths of Louèche.

As is seen from the plan, Fig. 1, three glaciers descend from the summit of Altels, 3636 m. (11,926 ft.) above sea-level—one in a northerly, another in a south-westerly, and a third, the middle one, in a north-westerly direction. It is this last, a so-called suspended or overhanging glacier, which, about 5 a.m. on the 11th of September, detached itself from the upper end at an altitude of 3300 m. (10,823 ft.), or about 1000 ft. below the summit, swept down a declivity 1400 metres in vertical depth, was thrown up 400 m. (1300 ft.) to the summit level of the precipitous mountain ridge on the opposite side of the valley, and thence rebounding, fell on, and spread in fan-shape over a rich and extensive pasture

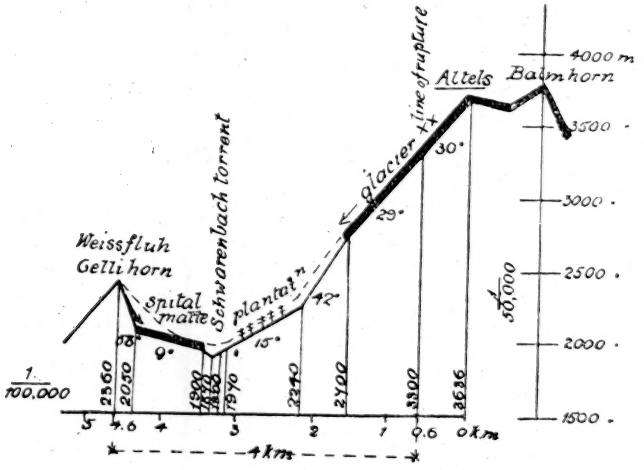


FIG. 2.

known as the Spitalmatte, which is now buried under ice and rock débris over an area of two square kilometres (nearly one square mile) to an average depth of two metres or 6·6 ft. The disaster involves, besides the ruin of the valuable Alpine pasture and the destruction of several châlets, the loss of six lives and upwards of 150 head of cattle.

The cross-section of the valley (Fig. 2) prepared by the writer from the Swiss Ordnance Contour Map, 1 in 50,000, shows the course of the avalanche, the entire distance covered by the latter, including the rebound, being about five kilometres or three miles. As is seen from the same section, the angle of inclination of the glacier itself was about 30 degrees, that of the declivity immediately below it is 42 degrees, while the upward slope of the Spitalmatte is 9 degrees, and the inclination of the Weissfluh and Gellihorn ridge is no less than 58 degrees. The line of rupture of the glacier below the summit of Altels is distinctly visible in the shape of an ice-wall about 40 m. (130 ft.) in depth, having the form of a concave

curve, while the opposite mountain ridge bears, up to its crest-line, numerous traces of the avalanche having been dashed against it and hurled up to its summit level.

The remarkable features of this ice-avalanche, and the conclusions which I have drawn from them, may be summed up as follows:—

1. The rupture of the glacier appears to have been produced by two separate cross-rents, which, during the hot and dry summer, extended and finally joined. The altered condition and appearance of the glacier was noticed from a distance the day before the ice-avalanche. The lower part of the glacier was probably set in motion by the unusually rapid melting of the ice due to the hot southerly wind (Foehn) which blew during the night. The disaster was thus produced essentially by meteorological causes.

2. In its descent from Altels, the avalanche crashed through, and carried bodily along with it, an extensive plantation, a fact which shows once more, if proof were wanted, that forest plantations are no effectual protection against avalanches.

3. The avalanche, in its descent, completely cleared the Schwartsbach torrent, which shows that it moved practically as a solid mass. Moreover, in its rebound from the opposite mountain ridge, and in its fall on the Spitalmatte, it buried the Gemmi bridle-path, but stopped short of the torrent, thereby fortunately preventing the formation of a temporary lake which would have endangered the Kander valley below.

4. The prodigious velocity of the avalanche and the pressure of the column of air displaced by, and pushed in front of it, are attested by a distinct blast-zone of débris, such as the remains of châlets, human bodies, cattle, etc., blown to a considerable height and distance.

5. The volume of the detached glacier and rock débris, about 100,000 square metres and 40 metres in average depth, is about four million cubic metres or tons, which estimate agrees pretty accurately with the volume of débris deposited on the Spitalmatte, viz. about two square kilometres to a depth of two metres. If we consider the avalanche as a moving mass possessing momentum, its kinetic energy is given by the formula—

$\frac{1}{2} m v^2$, in which $v^2 = 2 g h$; or $v = \sqrt{2 g h}$; and $m = \frac{\text{weight}}{10}$

The mean depth of fall (h), measured vertically, being 3000—1900 m. = 1100 m., the kinetic energy was 4400 million metre-tons. Assuming that half of this energy was expended in overcoming the various resistances in the descent, the remainder was still more than ample to raise the mass to a height of 400 metres on the other side of the valley.

6. The velocity of the fall, measured vertically, and without taking into account the various retarding resistances, works out 148 m. (485 ft.) per second, and that of the rise 90 m. (295 ft.) per second. Hence the avalanche, in falling, covered a distance of three kilometres (on an incline of 42 deg., or about 1 in 1) in 20 seconds; in rising, a distance of one kilometre in 10 seconds; and in rebounding, also

one kilometre in 10 seconds: total about 40 seconds. If to this we add 50 per cent. for the various retarding resistances, the estimated time within which the ice-avalanche did its work of destruction is not more than one minute.

It is a singular coincidence that a similar ice-avalanche occurred at the same spot over 100 years ago, on the 18th August, 1782. As in the year 1895, so also in the year 1782, great heat prevailed in the months of June, July, and August, and the rupture of the glacier was therefore in both cases due essentially to meteorological causes.[1] The present disaster falls short of the rock-fall of Elm (in the Glarus Alps) which occurred in 1881 on the same day, the 11th September, and caused the loss of 114 lives and 79 buildings, the volume of the débris being about double that of the Altels ice-avalanche. It also falls short of the ice-avalanche which destroyed the village of Randa in the Visp valley in the year 1819, the volume of glacier débris being in that case nearly four times that of the Altels avalanche. Still, the magnitude of the latter, and the scale on which Nature works in the Alps, may be gathered from the fact that the detached glacier swept down a declivity whose vertical height is thirteen times that of St. Paul's Cathedral (365 feet); that it was then hurled up to a height four times the elevation of that building; and that the volume of its débris under which the Alpine pasture is now buried, would suffice to cover to a depth of three feet the combined area (about 1000 acres) of Regent's Park, Hyde Park, and Kensington Gardens.

III.—On the Physical Conditions under which the Old Red Sandstone of Scotland was Deposited.

By Peter Macnair and James Reid.

I. Introduction.

THE physical conditions under which the Old Red Sandstone of Scotland was formed is a subject that has long occupied the attention of many of our leading geologists, from the time of Hugh Miller and Sir Roderick Murchison down to those of the present day. It has been variously regarded as of fresh-water and marine origin, as having been thrown down in lakes and in the open sea, or in inlets of the latter. But as yet the whole matter seems to remain an open question, which the unique physical and palæontological elements of the formation make difficult of solution.

This contribution to the controversy does not attempt to untie the Gordian knot, but is simply to show that much of the evidence freely assumed to be in favour of a fresh-water and lake origin for these deposits may or may not admit of proof, while on the other

[1] The precise date of the avalanche of 1782 is fixed by a public document, which was discovered through the efforts of Prof. Forel, of Morges, in the archives of Louèche, and enumerates the loss of life and property sustained on that occasion: "per terribilem et stupendam de summitate montis prolapsam glaciei quantitatem." On that occasion four men, who were crossing the Spitalmatte on their way home, and ninety cattle, were killed.

hand the evidence which is in favour of its entire extension over Scotland, and of its marine origin, has either been entirely overlooked or so minimized as not to be taken at its real value.

The first discoverers and workers amongst these rocks, Hugh Miller and Sir Roderick Murchison, firmly believed in its marine origin, and though Hugh Miller was not so much of a stratigrapher as a palæontologist, yet he clearly realized the fact that the Old Red Sandstone must have at one time covered the whole of the Scottish Highlands, as in his "Old Red Sandstone"[1] he speaks of a sea that extended from Ben Lomond to the maiden paps of Caithness. Sir Roderick Murchison, on the other hand, entered into a detailed study of its stratigraphical and physical structure and relationship, and it is mainly to his views we are persuaded the students of the Old Red Sandstone rocks of Scotland must finally return.

Stratigraphically, Murchison divided the Old Red Sandstone rocks of Scotland into three members—the upper, the middle, and the lower, each characterized by a distinctive fauna:—the lower group, as seen in Scotland, being principally developed in Forfarshire and Perthshire, and characterized by *Cephalaspis* and *Pterygotus*; the middle group, seen in Caithness, and containing *Dipterus*, *Osteolepis*, etc.; while the third or upper group, well developed in Dura Den, and containing *Holoptychius* and other characteristic forms, passes up conformably into the basement beds of the Carboniferous formation, there being always a decided break between the upper member and all the older rocks. He also correlated the Scottish Old Red Sandstone with its deep-water equivalent, the Devonian of England and Russia, pointing out that in the latter country the Devonian rocks containing marine shells were also interstratified with red sandstones, in which no shells were found, but which were replete with the piscine fauna common to the Scottish rocks.

Latterly, however, and principally through the work of Godwin-Austen, Ramsay, and more particularly Sir Archibald Geikie,[2] the Old Red Sandstone of Scotland came to be looked upon as a fresh-water deposit accumulated in isolated basins. The researches of the two first writers were principally directed to the petrological characters of the rocks. The latter was the first to isolate the Scottish areas of Old Red Sandstone into separate basins of deposit, with the distinctive names Lake Orcadie, Lake Caledonia, Lake Lorne, and Lake Cheviot. He believes they were all contemporaneous, doing away with the existence of the Caithness rocks as a middle group, and explaining the discrepancy of their fossil contents on the grounds that they are no greater than those of contiguous fresh-water basins at the present day. In his "Scenery of Scotland" he also presents some of the physical problems connected with the Old Red Sandstone; consequently it is mainly to the statements of Sir Archibald Geikie we now propose to revert, as being the principal authority for the isolated lake and fresh-water origin of

[1] "Old Red Sandstone," 7th edition, p. 53.

[2] See "The Old Red Sandstone of Western Europe"—Trans. Roy. Soc. of Edinburgh, vol. xxviii; and "Text Book of Geology."

these deposits. We propose to discuss the various points in the following order: first, the early Palæozoic mountain chain, in which we will give a resumé of what is known of that old continent upon which the later Palæozoic rocks were deposited as a nucleus; second, we will consider the general, physical, and stratigraphical evidence in favour of the marine and continuously ascending order of these deposits in Scotland through a lower, middle, and upper series. Under the division of the petrological consideration we will discuss those questions relating to the conditions under which these rocks were deposited, the almost universal presence of peroxide of iron in the rocks and their consequent barrenness of molluscan remains, and finally the palæontological evidence in favour of a marine origin for the organisms found in these deposits. We also in the course of the paper propose to show the "Character of the Strata" is entirely against its supposed deposition in small inland fresh-water lakes; that the absence of unequivocally marine fossils is not so complete as supposed, neither is it fatal to their marine origin; that land plants occur freely in undoubted marine strata; and that the existence of the representatives of ganoid fishes in the rivers and lakes of the present day is entirely out of evidence when we consider the immense number of these fossil fishes found in undoubted marine deposits both in England and Russia, and of their wide distribution over the continents of Europe and America.

II. The Early Palæozoic Mountain Chain.

Before passing on to discuss the physical, petrological, and palæontological evidence in favour of a marine origin for the Old Red Sandstone of Scotland, it would be here useful to give a brief recapitulation of the physical conditions of our country prior to the deposition of these later Palæozoic deposits. It is generally believed that in early Palæozoic time the main land mass must have lain somewhat to the north-west of the present continent of Europe, and may have partly existed in what is now the deep basin of the Atlantic. The old Archæan gneiss of the islands and northern Highlands seems to represent part of the primitive core round which the later Palæozoic rocks were accumulated. We do not now propose to discuss these early Palæozoic rocks, but to us those massive red sandstones and conglomerates of Loch Torridon only shadow forth the same physical processes that were at work in the still later Old Red Sandstone age; lying as they do upon the older Archæan rocks, they are the undoubted littoral accumulations along that ancient coast-line which are invariably seen to accompany a great period of mountain-building, indicating that a rapid process of subaerial denudation must have been at work in the higher regions, the detritus being swept out through the old river courses and subsequently rearranged along the shore line by the action of the sea. But to this point we propose to return later on. Immediately on the top of these Torridon sandstones and conglomerates, and separated by a strong unconformability, we find a great series of metamorphosed rocks of Cambrian, Ordovician, and Silurian age,

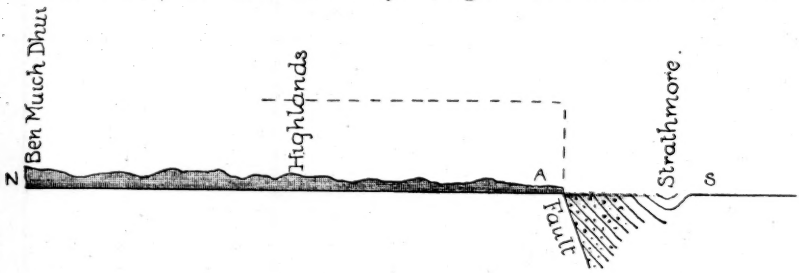
forming the main mass of the Scottish Highlands. In the intervening period which elapsed between the deposition of the lowest member of this group and the highest, the whole series of beds were subjected to a great process of upheaval into a mountain chain of elevation. It seems to have received its maximum of corrugation and plication in that difficult and complex area in the north-west of Sutherlandshire. Receding to the south-east we find the curving of the beds become more and more gentle till they reach the comparatively unaltered rocks of the southern uplands. The great mass of this mountain chain, then, must have lain to the north-west of the present Old Red Sandstone area, and we now proceed to show how after this long period of upheaval the mountain mass once more began to sink below the level of the sea, and that gradually the waters of the Old Red Sandstone sea levelled it down to the very core.

III. Physical and Stratigraphical Considerations.

We now pass on to notice some of the physical and stratigraphical aspects of the matter. A consideration of the deposits lying immediately upon the metamorphosed rocks which then formed land leads us to the conclusion that the whole of this continental area must have been in a gradually sinking condition, and that these huge masses of conglomerate, lying at the local base of the Lower Old Red Sandstone wherever the latter is exposed, point unmistakably to the existence of a great series of unstable sea margins, slowly creeping backwards upon the main mass of the gradually sinking land. Along the flanks of the Grampians, and now exposed by a powerful fault, we have a great mass of conglomerate, consisting in some cases of boulders nearly six feet long. The conglomerates range across the country from shore to shore; in some cases north of the line of fault we have these conglomerates still occupying their normal position upon the older schists and grits. If the effect of this fault were undone, and these conglomerates were raised to their original position, they would stretch far over the Grampians along with the higher deposits of sandstones and their fish remains, which now occupy the central valley of Strathmore. The following diagram, drawn to scale, will show this very clearly (see p. 110).

The dark part of the section to the north represents the present elevation of the Highlands above the level of the sea drawn to scale, and culminating in Ben Muich Dhui. To the south of the line of fault are shown the massive beds of Old Red Sandstone conglomerates dipping at high angles to the south-east, and estimated to be about 20,000 feet in thickness, about four times the present height of Ben Muich Dhui. At the point *A*, immediately to the north of the line of fault, and resting directly upon the old crystalline schists, are often to be found patches of the basal conglomerate of the Lower Old Red Sandstone still occupying its normal and unaltered position, so that if the effect of the great fault were undone, and the whole Old Red Sandstone deposits of Strathmore were upraised to their original position, they would overlook

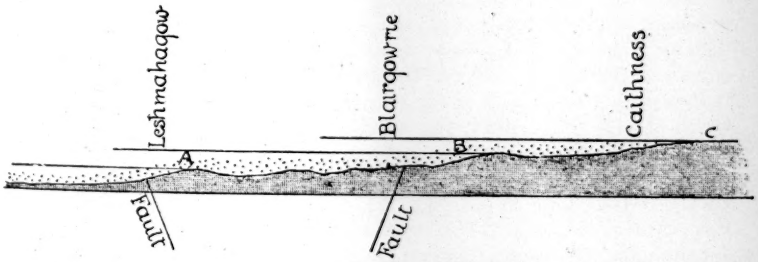
the Highland area to an altitude of four times its present highest elevation. Of course we do not mean to say that the Highlands have not suffered any denudation since its mantle of Old Red Sandstone rocks was swept from it; but what we do mean to maintain is, that supposing the original mountain chain was as high as the present Alps, still these deposits would have swept over it and united the so-called basins of Lake Orcadie and Lake Caledonia. It is impossible to seriously consider the idea that these basins continued to sink *pari passu* with the deposition of their sediments, the narrowness of the ridge separating them entirely precluding the idea, as the bottom beds would be contorted and folded long before the upper beds of the 20,000 feet of sediment were laid down, whereas we do not find a break in the whole series. On the other hand, it would be nigh impossible to exclude the sea from such a sinking area and for such a length of time. As if to make their original connection quite sure, outliers and fragments are found on the ridge of crystalline rocks, as at Mealfourvonie to the height of 2,284 feet, at Tomintoul and Rhynie, right on what must have been



the centre of the ridge, had separate basins existed, and where there could have been no deposits. Sir A. Geikie[1] accounts for these by supposing them to have been little isolated basins or arms of the lake running into the separating ridge. But this method of argument is exceedingly specious; it would be much more scientific to consider them as outliers of a great deposit that once covered the Highlands, the remainder of which has now been entirely swept away. Again, in Caithness there are many evidences of the denudation of these basal conglomerates from the surface of the old marine plain upon which they were laid down. In Ben Gnam the conglomerates cap the top of a mountain 1,936 feet above the sea-level; the conglomerate is exceedingly coarse, sometimes the boulders being two feet in length, the total depth of the sandstone formation on this mountain being estimated by Geikie at 1,000 feet. Another instance is mentioned by Sir A. Geikie[2] in his Memoir on the Old Red Sandstone of Western Europe, where he says he was informed by Mr. Crawford, Tongue House, that on Ben Armunin, a mountain rising to a height of 2,338 feet, in the heart of Eastern Sutherlandshire, conglomerate occurs. There can

[1] "Scenery of Scotland," 2nd edition, p. 141.
[2] Trans. Roy. Soc. of Edinburgh, vol. xxviii, p. 383.

be little doubt, as the older geologists believed, that the whole of the Highlands of Scotland were at one time covered with a vast thickness of Old Red Sandstone rocks. The period at which this denuding process must have begun would of course be subsequent to the metamorphism of the lower Palæozoic rocks themselves, and was probably contemporaneous with the deposition of the higher members of the Upper Silurian age. That this is so is evident from the manner in which the latter pass up conformably into the lower Old Red Sandstone at Leshmahagow, in Lanarkshire. They there contain an abundant supply of Upper Silurian forms, and undoubtedly go to prove that the work of carving out the great chain of upheaved and metamorphosed older Palæozoic rocks had already commenced along the skirts of the chain. These deposits seem to us to represent somewhat of a deep-water aspect, and it is very probable that the corresponding littoral deposits of conglomerate may lie somewhere beneath the later Carboniferous formations of the midland valley. Along the northern margin of the midland valley no evidence has yet been found of the Upper Silurian rocks as seen at Leshmahagow, though some of the basal conglomerates may be upon the same horizon, representing the littoral deposits to the north of the Leshmahagow beds on the south. The occurrence of *Pachytheca* in the sandstones at Murthly seems to indicate that the old Upper Silurian flora had not yet passed away when these rocks were deposited. The discrepancies between the fossils of Lanarkshire and Forfarshire on the one hand, and between the fossils of Forfarshire and Caithness on the other, are so great that we are driven to the conclusion that the three must represent different horizons of a gradually ascending and overlapping series of beds, each marked by a distinctive fauna and flora, and also by strong lithological differences. The following section will better explain our position.



During Upper Silurian times, the mountain chain was depressed as far as the point marked *A*, these deposits being now shown passing up into the Old Red Sandstone. By the time the chain had been depressed as far as *B*, the Silurian types had passed away, and were now represented by those organisms found in Forfarshire. Finally, the whole mountain mass was so far depressed as to cover the entire highland area as seen at *C*, when the Forfarshire types had, in their turn, been superseded by those of Caithness.

Subsequent to this, the midland valley was depressed between the powerful trough-faults; the upturned edges at the south showing Silurian types, and to the north, those of Old Red Sandstone times. Had these rocks been deposited in a basin, we should have expected the strata to be more or less homologous on each side of the basin; but this, as we have shown, is decidedly not the case. Jukes-Browne,[1] in his "Building of the British Isles," makes some very pertinent remarks upon this subject. He says: "From the proofs which have been adduced of the original wide extension of the Old Red Sandstone, it might be thought that the three principal basins could hardly have been separate lakes, but must have been inlets proceeding from one large inland sea, the greater part of which lay to the east of Scotland." And, indeed, so far as the stratigraphical evidence goes, this would be the most natural conclusion, for the lithological differences between the strata of the several basins are hardly greater than the differences which exist between the Lanark and Forfar types in the Caledonian basin. The palæontological differences are, however, very much greater; the piscine fauna of the Forfar and Caithness flags being so distinct, that Sir R. Murchison thought they could not be of the same age, and was led to suggest that the Caithness flags formed a middle group distinct from the Lower Old Red, and of younger date than the flags of Arbroath, in Forfarshire. Further on, he says, there is less evidence for regarding the Cheviot basin as distinct from the Caledonian, as no fish have yet been found in the Cheviot district, and we do not know how far the Lower Old Red originally stretched over the southern uplands. We have lately been examining the Lorne basin, and nothing will persuade us that it is other than an outlier removed and preserved from the main mass by the effects of some powerful faults. The presence of such extremely large boulders in its massive conglomerates as that seen in the base of the well-known Dog-stone of Dunnoly, entirely precludes the possibility of its being formed in a basin only a few miles wide. The stratigraphical evidence from the volcanic phenomena we also consider is strongly against the basin origin of these deposits; for instance, a great mass of volcanic rock forming the Sidlaws and Ochil hills is found interbedded with the sediments of the so-called Lake Caledonia basin, at a height of several thousand feet above the base. Now in the whole of the 16,000 feet of Lake Orcadie this volcanic zone is entirely absent, which, I think, points to the fact that these two basins could not have been contemporaneous, for had that been so, further evidence of this extensive volcanic activity would have been found in Lake Orcadie when we consider the narrowness of the ridge that must have separated the two basins.

The process which metamorphosed and plicated these lower Palæozoic rocks into a true mountain chain also upheaved them above the general level of the surrounding sea, when they immediately became the prey of the subaerial denuding agents. Then followed a long and intense period of subaerial and marine

[1] "Building of the British Isles," p. 61.

denudation, commencing in Upper Silurian times and lasting all through the long period of the Lower Old Red Sandstone age. It is evident from a consideration of these Upper Silurian and Lower Old Red Sandstone deposits that the old Palæozoic mountain chain was gradually sinking along its flanks, and that the sea, slowly advancing upon this sinking land, laid down these deposits, the first and lowest of which we see in the south of Lanarkshire, and the highest and latest in the topmost beds of the Lower Old Red Sandstone as developed in Caithness. It has generally been believed that all the stratigraphical evidence has been in favour of these separate areas of Old Red Sandstone being also separate basins of deposit, but it will be found that however difficult it may be to explain the exact condition under which these rocks were accumulated, one thing is certainly evident, and that is that they were not deposited in isolated basins as maintained by Godwin-Austen, Ramsay, and Geikie.

In Sir Archibald Geikie's "Scenery of Scotland"[1] will be found the most detailed work that has yet been done with regard to the physical evolution of our country, the opinions contained in it being those generally accepted and followed by present-day geologists. Referring to the second edition of that work at p. 137 on the chapter dealing with the tableland of the Highlands, he says: "The long flat surfaces of the Highland ridges cut across the edges of the vertical strata mark, I believe, fragments of a former base level of erosion; in other words, they represent the general submarine level to which the Highland region was reduced after protracted exposure to subaerial and marine denudation. . . . . And in this rolling plain we should find a restoration of the bottom of a very ancient sea." He further goes on to say: "The first fact which a study of the topographical features and geological structure of the Highlands establishes is, that the ancient land formed after the stupendous movements that gave the rocks of the region their present character was worn down by prolonged denudation. Its mountains were levelled, its valleys were planed down, and finally the region was reduced to a base level of erosion beneath the waves either of a group of great lakes or of the sea."

Let us now examine more carefully, and in greater detail, these statements of Sir Archibald Geikie. The latter part of the paragraph just quoted seems to us to indicate in a few words the rather indefinite idea which Sir Archibald Geikie gives in his "Geology and Scenery of Scotland" of one of the most important points in the physical evolution of our country. He says that the old crystalline or metamorphosed Lower Silurians were reduced to a base-level of erosion, beneath the waves, either of a group of great lakes or of the sea. Sometimes in the course of this chapter, we would think it was the sea. For instance, as in the sentence just quoted, where he says, "In this rolling plain we should find a restoration of the bottom of a very ancient sea." Again, in a few

[1] "Scenery of Scotland," 1st and 2nd editions, under the heading 'Tableland of the Highlands.'

sentences previous to this, he says they represent the general submarine level to which the Highland region was reduced. Once more, as before quoted, he does not seem to be very sure as to whether this base-level of erosion was the action of a group of lakes or of the sea. In trying to fix the geological date of this vast denudation, he says that it must have been accomplished between the time of the Lower Silurian and that of the Lower Old Red Sandstone system. Probably the waste began in the Lower Silurian period and continued during the vast series of ages that extended into the period of the Old Red Sandstone. Here again, we would think he was referring this immense denudation to the group of fresh-water lakes, as he refers to it as being continued during the vast series of ages that extended into the period of the Old Red Sandstone.

We must confess to having a great difficulty in following Sir A. Geikie's description of the succession of physical events that took place immediately after the plication and upheaval of the old Palæozoic mountain chain. But we think the following may be taken as a fair representation of his meaning—That after the plication and metamorphism of the crystalline rocks of the Highlands, the whole mass was reduced to a plain of marine denudation by a sea which has left no traces whatever of this immense denudation in the shape of later deposits, and that afterwards this plain of marine denudation was depressed into regions occupied by fresh-water lakes which, creeping backwards, threw down the deposits now known as the Lower Old Red Sandstone formation. Generally speaking, the whole tenour of the chapter dealing with the tableland of the Highlands seems to indicate that an extensive marine denudation reduced the massive mountain chain of the Highlands to a base-level of erosion altogether distinct from the later denudation which threw down the massive conglomerates of the Old Red Sandstones with its 20,000 feet of sandstones and shales.

Now we would maintain that this first marine denudation, which levelled down the old Palæozoic mountain chain, was identical with the deposition of the Upper Silurian and Lower Old Red Sandstone rocks, pointing out that, though Sir Archibald Geikie believes that it was the sea which levelled down the old continent, he cannot show us anywhere the remains of this immense denudation, all the later rocks lying upon it being of Old Red Sandstone age, and consequently having a fresh-water origin. Further, we cannot see how, if the whole land surface were reduced to a level plain first by marine denudation, this plain could be now preserved, seeing that subsequently it was ridged up into isolated basins to hold the fresh-water lakes. It is evident, then, that Ramsay, Geikie, and their followers distinctly recognize two periods of denudation after the plication of the Lower Silurian rocks into a mountain chain. The first period of denudation cut down this mountain chain to a dead level of erosion, called by them a plain of marine denudation, which was produced by the action of the sea. This period, however, strange to say, seems to have left no traces behind

in the shape of marine deposits, for immediately resting upon this ancient plain, wherever it has been preserved, we have the great basal conglomerates of the Old Red Sandstone, which they all agree in referring to a lake or fresh-water origin.

The amount of misconception that exists as to the succession of events after the plication of these early Palæozoic rocks is indeed wonderful, and may be traced principally to these theories of the physical and geological development of our country given in Sir A. Geikie's "Scenery of Scotland," the following being a very fair example. Prof. Davis,[1] of Harvard University, in a paper on the rivers of England contributed recently to the Royal Geographical Society's Magazine, speaking of the marine plain of denudation, as described in the aforementioned work, says: "Although perhaps not absolutely stated, it is clearly implied that it was Devonian erosion by which the once low and comparatively even surface of the now uplifted and dissected Highlands was produced; it is plainly manifest that Devonian erosion consumed a great volume of the contorted and overthrust rocks of the Highlands: witness the great volume of the Devonian strata lying unconformably upon the Highland rocks, and the identity of the Devonian conglomerate pebbles with the rocks of the older terranes. It may indeed be well argued from Sir A. Geikie's essay on the Old Red Sandstone of Western Europe that a vast denudation was accomplished in earlier times than the Old Red Sandstone period, and that by the close of that period the Highland region must have been truly a diminished lowland, a peneplain of small area and moderate relief." This is a very good example of the misconception and general indefiniteness which accompany Sir A. Geikie's description of the physical events following the plication of the crystalline rocks of the Highlands, for Prof. Davis speaks of Devonian seas having cut down the Highlands to their base-level, and of conglomerates belonging to that age resting upon them, and then of Old Red Sandstone conglomerates, as if there were two distinct sets of rocks in Scotland, one marine and Devonian, the other fresh-water and of Old Red Sandstone age. Of course the error is quite excusable in one who has never studied the rocks of our country, but only read of them in the "Scenery of Scotland."

IV. Petrological and Other Considerations.

We have already noticed the strong similarity between the conglomerates of the Torridon Sandstones and those of the later Old Red Sandstone rocks. Both of them show evidence of glaciation, and, as has recently occurred to us, this may be connected in some way with the fact that they are both seen to follow a great process of mountain-building. This fact, we think, would indicate that the great mountain mass had been upheaved above the limit of the snow-line. The consequent descent of glaciers having played an important part in contributing their morainic débris to the formation of these massive conglomerates now lying at the base of both the

[1] Geographical Society's Journal for 1895.

Pre-Cambrian and Old Red Sandstone deposits, their origin is not, we believe, to be sought for in any lacustrine deposit, as has been maintained by Ramsay, Geikie, and Hull. They are rather types of a great series of shore deposits gradually accumulating along the margin of a slowly sinking continental area, which in its upper regions is rapidly undergoing subaerial denudation. This type of deposit it not uncommon all through the geological scale, and to it we believe the Old Red Sandstone conglomerates of Scotland belong. Prof. Bonney[1] makes interesting remarks upon this point in his address to the British Association in 1886. He there says that "Pebbles indicate the action of the waves of the sea or of strong currents, marine or fluviatile." Further he continues: "The waves of lakes have also some rounding effect, but this, except in the case of very large lakes such as Lake Superior, is not important, and such cases are, of course, not of common occurrence." As we have already pointed out, the massive conglomerates of such a small basin as we are led to believe Lake Lorne must have been, and, what is still further in evidence, the much smaller basins that are alleged to have existed on the separating ridge between Lake Caledonia and Lake Orcadie, entirely preclude, even from a petrological point of view alone, the possibility of their being other than outliers from the main mass. The whole petrological aspect of the Old Red Sandstone rocks, as seen in Scotland, is, of course, highly indicative of their littoral origin; the entire absence of any of the deeper oceanic types of sedimentation, such as shales and limestone, also confirming this view. The rocks as seen in Caithness, Forfarshire, and Perthshire, and generally in the valley of Strathmore, mainly consist of great beds of grey and red sandstone, with occasionally local deposits of conglomerate, the great feature of the whole being their characteristic red colour. Now we think that this red colour, due to the presence of the red oxide of iron in the rocks, cannot be fairly claimed as an argument for the fresh-water origin of these deposits. Prof. Gosselet has shown that in the Devonian basin of Dinant, the same beds are in one part red and barren of organic remains, and in another part of the same area are of the usual colour and are full of marine fossils. With Sir Charles Lyell[2] we ask the question, Why should shells and corals be generally wanting in all sedimentary rocks, the colour of which is determined by the red oxide of iron? and we believe that the answer cannot lie in the assertion that they are all fresh-water deposits, seeing that even in such undoubted marine deposits as the Devonian, Carboniferous, and Permian formations, it is common in the ordinary beds to find corals and shells, while those coloured with peroxide of iron are entirely barren of organic remains. The solution of the problem rather lies in the fact that the presence of peroxide of iron in these rocks is inimical to the preservation of fossils with a calcareous test, and that more especially in the case of sandstones, which even when composed of pure silica are well known to be a bad medium for the preservation of molluscan and other similar organic remains.

[1] British Assoc. Report, 1886. [2] "Elements of Geology," 3rd edition, p. 435.

IV.—Woodwardian Museum Notes.

Notes on the Evolution of the Genus *Cheirurus*.

By F. R. Cowper Reed, M.A., F.G.S.

THE genus *Cheirurus* offers an interesting study in evolution. Barrande, in his monumental work on the Silurian System of Bohemia,[1] drew up a classification of the genus based principally on the character of the pleural grooves. Thus he divided the species into two sections—

Section I. Pleural groove parallel to the borders and slightly marked. 10–12 segments to the thorax.

Section II. Pleural groove oblique and deep. 11 segments to the thorax.

The first section he subdivided into three groups according as the species had 10, 11, or 12 thoracic segments. The second section he split into two groups: (1) with glabellar side-furrows not united on the axis; (2) with glabellar side-furrows united on the axis. This last group corresponds with Salter's subgenus *Crotalocephalus*. Another provisional group was made to contain several forms whose position could not be then established.

The restriction of Section I to the Lower Silurian and of Section II to the Upper Silurian and Devonian is also commented on by Barrande, as well as the almost complete limitation of the second group of Section II to the Devonian. The relationships of the various species are also minutely discussed; and on plate vi of the Atlas there is given the complete series of modifications in the pleuræ between the extreme terms represented by *Ch. claviger* of Section I and *Ch. gibbus* of Section II.

Schmidt[2] has more recently discussed the affinities of the various species and divided the genus into two sections, the first of which is characterized normally by the possession of eleven thoracic segments, each pleura being divided by a constriction into an inner and an outer portion. The inner portion is marked by a longitudinal or a diagonal furrow, and is also possessed of a narrow articulating band along its anterior and posterior borders, which terminates at the constriction in a recurved, swollen, hook-like process. A similar band with hook-like process is found on each side of the axial portion of the head-shield along its posterior border. To this section belong *Cheirurus* (*sens. str.*) and *Cyrtometopus*. These two forms mark two groups.

Group 1 of this section of Schmidt consists of *Cheirurus* (*sens. str.*) (type *Ch. exsul*, Beyr.). All the species have a diagonal furrow on the inner portion of the pleura, and the outer portion is swollen at its base. The marginal furrows of the head-shield are always distinct, and run into the axal furrows without interruption; the latter diverge more or less in front. The glabella

[1] Syst. Silur. Bohême, vol. i: Trilobites (1852), p. 770; and Suppl. to vol. i (1872).

[2] Revis. d. Ostbalt. Silur. Trilob. 1881, pt. i, p. 121.

is almost rectangular or slightly wider in front, and the side-furrows are distinct. From the first side-furrow of the glabella a prominent ridge runs to the eye. The eye is for the most part large, situated in the middle of the cheek, with rounded triangular eye-lobe without an oblique furrow at the base. The genal angles are produced into long horns.

Group 2 consists of the somewhat heterogeneous subgenus *Cyrtometopus*. All the species have a longitudinal furrow on the inner part of the pleuræ. The marginal furrows of the head-shield do not run into the axal furrows, or only pass feebly over the anterior wing of the fixed cheek. This swollen anterior wing of the fixed cheek on the inner side of the anterior branch of the facial suture is an important feature. The shape of the glabella varies considerably: thus, in *Cyrto. Plautini* (Schmidt) it is parallel-sided, reminding one of *Cheirurus* (*sens. str.*), while in *Cyrto. clavifrons* (Dalm.) and *Cyrto. affinis* (Ang.) it is oval. The side-furrows of the glabella are always distinct, and the basal lobe is incompletely circumscribed, except in *Cyrto. pseudohemicranium* (Nieszk.) which has a broad and deep third side-furrow completely surrounding the basal lobe. This species also has an almost obsolete first side-furrow to the glabella.

The strange subgenus *Sphærocoryphe* (which probably ought to take generic rank) is closely linked on to the true *Cyrtometopus* by *Cyrto. pseudohemicranium* and *Cyrto. aries* (Eichw.); but the extraordinary inflation of the anterior position of the glabella, the teeth on the lateral margin of the head-shield, and the reduction in the number of the thoracic segments (8–11? but commonly 9), sufficiently distinguish it.

Section II of the whole genus *Cheirurus*, according to Schmidt, includes three subgenera—*Nieszkowskia*, *Pseudosphærexochus*, and *Eccoptocheile*. The subgenus *Nieszkowskia* is made by Schmidt to receive certain species which had been placed by Nieszkowski in the genus *Sphærexochus*, and by Angelin in *Cyrtometopus*. *N. cephaloceros* (Nieszk. sp.) may be taken as the type.

The characters common to the whole section are the possession of twelve thoracic segments; the absence of any constriction of the pleuræ, so that they lie close to one another along their whole length; the presence of a longitudinal row of puncta[1] instead of a furrow on the inner portion of each pleura; the presence of a narrow articulating band on the anterior border of the inner portion of each pleura; and the abrupt termination of this band without a hamate process. There is a feeble indication of this band on the posterior border of the head-shield. The three subgenera form three groups.

Group 1 consists of the subgenus *Nieszkowskia*. In this subgenus the glabella is swollen posteriorly, and often passes into a hump or spine. All the side-furrows are directed backwards, and the third side-furrow, which is stronger than the other two, runs in a curve towards the neck-furrow, but does not reach it. The free cheeks

[1] In *Pseudosphærexochus* these puncta are very faint or absent.

are triangular and small, since the posterior branch of the facial suture cuts the outer margin far forward. The genal angles are produced into long divergent horns. The pleuræ have a weak fulcrum, and while the inner portion has a longitudinal row of puncta, the outer portion is smooth and produced into a sword-shaped point. The pygidium is always four-pointed, and the posterior pair of points is embraced by the larger anterior pair.

Group 2 of Section II is formed by *Pseudosphærexochus*, the type of which is *P. hemicranium* (Kut. sp.). The glabella resembles that of *Sphærexochus*; the first side-furrow stands almost vertical to the axal furrow; the third side-furrow, which is much stronger than the two first, is also almost vertical to the axal furrow for part of its length, but then bends back and becomes weaker, reaching the neck-furrow only as a faint groove. The free cheeks are large and form almost the whole side of the head-shield, for the outer limb of the facial suture cuts the margin only a short distance before the genal angle. (In *Sphærexochus* this outer limb reaches the margin at the genal angle.) The pleuræ have a distinct fulcrum; the inner part of each pleura is swollen, and possesses either an almost obsolete row of puncta or no puncta or groove at all; the outer part is long and conically pointed. The pygidium has four pairs of pleuræ with free pointed ends.

Eccoptocheile is not described by Schmidt, since it does not occur in the Silurian of the East Baltic provinces; but he alludes to the English species *E. Sedgwicki* (M'Coy) as belonging to this section.

The earliest type of *Cheirurus* in Britain occurs in the Upper Tremadoc of Portmadoc, and was placed by Salter in the subgenus *Eccoptocheile*. This species [*Ch.* (*E.*) *Frederici*, Salter], though undoubtedly closely allied to the members of Section II in Schmidt's classification, yet shows some important points of difference to the typical *Eccoptocheile*. The Tremadoc form has eleven or twelve[1] thoracic segments, each of which is deeply grooved along its middle almost to its free end. There is no row of puncta in the groove. The great length of the groove, the absence of puncta in it, the loosely-built structure of the thorax, and the close similarity of the pygidial to the thoracic segments, look like primitive characters. I am inclined to think that this species is sufficiently distinct from the typical *Eccoptocheile* to warrant the creation of a new subgenus for its reception. This subgenus may be termed *Anacheirurus*.[2]

The next species as we ascend the stratigraphical series is *Ch.* (*Eccopto.*) *pectinatus* (Salter MS.), of the Lower Llandeilo or Arenig of Shelve; the only specimens with which I am acquainted are in the Museum of Practical Geology, Jermyn Street, and no description of its characters has been published. It seems closely allied to the

[1] The type specimens on which the species was founded are not sufficiently well preserved for one to be sure of the number of segments—a point Salter notices.

[2] The pygidium with seven segments ascribed to this species (Salter, Mon. Brit. Trilob. Pal. Soc., pl. v, fig. 21, p. 75) probably belongs to a distinct species, or even subgenus; but our ignorance of the other parts of the trilobite to which it belonged prevents us coming to a decision about its exact position.

better known *Eccoptocheile Sedgwicki* (M'Coy), which occurs in the Upper Llandeilo of Wales. The latter species shows on each of its twelve thoracic pleuræ a longitudinal groove extending fully three-fourths of the whole length of the pleura, and furnished with a row of puncta lying in it. The pygidium, while showing four segments on the axis, has only three pairs of pleuræ, indicating a condensation and abbreviation of this part of the body. The pygidial pleuræ are closely similar to those of the thorax, preserving the longitudinal groove and row of puncta. M'Coy's original figured specimens of this species are in the Woodwardian Museum, as well as those of *Ch.* (*Anach.*) *Frederici*. The presence of the row of puncta in the longitudinal pleural groove, and the shortening of the latter, are characters intermediate between those of *Ch. Frederici* and the next group of species. This group, which represents the next stage in the development of the genus, includes several Bohemian species (*e.g. Ch. claviger*, Barr., *Ch. pater*, Barr., etc.).[1] The longitudinal pleural groove is reduced in length so as to furrow only about half the pleura, which can therefore be considered to consist of two portions —an outer ungrooved portion and an inner grooved portion. A row of puncta is present in the groove. The Bohemian forms, however, have curiously only ten thoracic segments, which probably points to an arresting of the process of segmentation at a pre-adult stage. The preservation of an adolescent character in the adult is, of course, well known in many groups of organisms, and I do not attach any subgeneric importance to it. The pygidium resembles in the number of the pleuræ and condition of the axial portion that of *E. Sedgwicki*, but the greater dissimilarity of the pygidial to the thoracic pleuræ points to a further specialization of the pygidium. The head-shield demands no special notice, since its characters are essentially the same as those in *E. Sedgwicki*. *Ch. claviger* occurs in Dd 3 and Dd 4, but principally in the latter, which corresponds with the lower part of our Bala. The allied *Ch. scuticauda* (Barr.), which shows a slightly greater reduction in length of the pleural groove and line of puncta, has the atavistic character in the pygidium of four pairs of pleuræ, which, nevertheless, by their form, etc., show some specialization. A reversion to more primitive and ancestral conditions in the case of the pygidium is by no means rare in this genus, as we shall see. *Ch. scuticauda* occurs in Dd 3 of Bohemia. *Ch. pectinifer*, Barr., of Dd 5, with its Cyrtometopian head and reduced pleural groove, appears to belong to about this stage.

The species which comes next in the series is *Ch. tumescens* (Barr.). It seems to be closely related to *Ch. scuticauda*, for it possesses a very similar pygidium, and also commences on the same horizon (Dd 3), though ranging up to Dd 5. In this species also only ten thoracic segments are present. The chief advance is shown in the constriction which occurs between the outer and inner portions of

[1] It is remarkable that this group, which includes the earliest members of the genus occurring in the Bohemian basin, has not yet been found in northern Europe (see sequel).

the pleura, and the greater development of the articulating band on the inner portion of the pleura. Closely allied forms are *Ch. insocialis*, Barr., and *Ch. gryphus*, Barr., of Dd 4 and Dd 5. In all these above-mentioned species the basal lobe of the glabella is incompletely separated, for the third glabellar side-furrow does not unite with the neck-furrow. If we regard the head-shield as composed of several fused segments, we must look upon this non-union as a primitive feature. The presence of an anterior wing to the fixed cheek not crossed (or only very feebly) by the marginal furrow is also a noticeable character in all the *Eccoptocheile* group. About this point the main stem seems to give off two branches which lead to such diverse forms as *Pseudosphærexochus* and *Crotalocephalus* respectively.

Turning first to the branch that ends in *Crotalocephalus*, we find that we are leaving Section II of Schmidt and entering upon his Section I through a considerable number of intermediate forms linking *Eccoptocheile* with *Cyrtometopus*. The subgenus *Cyrtometopus*, with its rather heterogeneous and ill-defined characters, first demands our attention. In it the number of eleven thoracic segments, characteristic of Schmidt's Section I, with constricted pleuræ, is met with. The pleural groove is confined to the inner portion of the pleura, and is longitudinal; the basal lobes of the glabella are incompletely separated (except in *Cyrto.*? *pseudohemicranium*, Nieszk., which belongs to a minor lateral branch); the fixed cheek has an anterior wing not crossed (or only feebly) by the marginal furrow just as in the typical *Eccoptocheile*. The type of the subgenus is *Cyrto. clavifrons* (Dalm.). The pygidium varies somewhat, but most commonly its anterior pleuræ are enlarged and project behind the posterior ones, which are of smaller size. There are normally only three pairs of pleuræ with free ends in the pygidium, but the fourth pair is represented by a single median terminal piece.

Ch. juvenis (Salter), which was placed by its author in the ill-defined subgenus *Actinopeltis*, has close affinities to a true *Cyrtometopus* in the characters of the head-shield and pygidium, but the complete separation of the basal lobes from the glabella by the third side-furrow is a distinguishing feature, and suggests an alliance with *Cyrto.*? *pseudohemicranium* (Nieszk.). The position of the side-furrows and course of the facial suture in some specimens show some similarity to those of *Pseudosphærexochus*, but I strongly suspect that two or more distinct species, and perhaps even different subgenera, have been included under the specific title of *Ch. juvenis*.

The two species *Cyrto.*? *pseudohemicranium* (Nieszk.) and *Cyrto.*? *aries* (Eichw. sp.) may ultimately need the creation of a new subgenus intermediate between *Cyrtometopus* and the strange *Sphærocoryphe*.

The reasons for the removal of these forms from other subgenera are at present (1) the complete separation of the basal lobes by the strong third glabellar side-furrow joining the neck-furrow, and the smaller elevation of these lobes than the rest of the glabella;

(2) the very weak development of the two anterior side-furrows. Though in *Cyrto.*? *aries* the basal lobes are not completely circumscribed, yet the whole head-shield resembles in many important features *Cyrto.*? *pseudohemicranium*, and Schmidt (*loc. cit.* p. 123) holds that they are closely allied. Eichwald [1] considered *Cyrto.*? *aries* to be a species of *Sphærocoryphe*; Hoffmann [2] held it to belong to *Sphærexochus*; and Nieszkowski [3] and Steinhardt [4] also place *Cyrto.*? *pseudohemicranium* in *Sphærexochus*. The pygidium ascribed to *Cyrto.*? *pseudohemicranium* also shows quite peculiar characters. *Hemisphærocoryphe* would be a suitable name for these forms. They have some points of similarity to *Ch. globosus* (Barr.) from Dd 4 and Dd 5 of Bohemia, a point noticed by Schmidt (*loc. cit.* p. 123). This Bohemian species, while possessing eleven segments, the number typical of Schmidt's Section I, and constricted pleuræ with hamate processes to the articulating bands, has merely a longitudinal row of puncta on the inner portion of each pleura instead of a furrow. It has also an apparently complete communication of the marginal with the axal furrow, and the basal lobe of the glabella is cut off by the union of the third side-furrow with the neck-furrow. Its pygidium is, however, very different from those of *Cyrto.*? *pseudohemicranium* and *Cyrto.*? *aries*, being furnished with four pairs of pleuræ with free terminations, allying it to *Ch. tumescens* and other Bohemian species. I am therefore inclined to think that *Ch. globosus* belongs to a small side branch, and is not in the direct line of ancestry of later forms.

Cyrto.? *pseudohemicranium* and *Cyrto.*? *aries* form a connecting link between *Cyrtometopus* and *Sphærocoryphe*, as before mentioned. The latter subgenus has, in common with *Cyrto.*? *pseudohemicranium*, the inflated anterior portion of the glabella, the separated basal lobes, and the faint first and second side-furrows; and, so far as is known, the pleuræ are similar in both cases. But the reduction in the number of the thoracic segments to eight or nine (according to Angelin), the much greater inflation and protuberance of the glabella, and the lateral teeth to the head-shield, are important differences. The pygidium has three pairs of pleuræ according to Kutorga, and has the appearance of considerable deviation from the ordinary types in the genus *Cheirurus*. *Sphærocoryphe*, in fact, appears to be at the end of a highly specialized small side-branch, which died off in Silurian times.

The *Staurocephalus*? *unicus*, described first by Wyville Thomson [5] from the Bala beds of Ayrshire, is really a *Sphærocoryphe*, and seems to be the only British representative of the subgenus. On the Continent the subgenus is confined to Ordovician strata.

[1] Eichwald. Lethæa rossica, 1860, p. 1408, T. lii, fig. 31.

[2] Hoffmann. Sämmtl. Trilob. Russl. in Verh. d. mineralog. Gesellsch. 1858, p. 30, T. i, fig. 5.

[3] Nieszkowski. Zusätze z. monogr. d. Trilob. d. Ostseeprov. im Archiv. für Naturk., Liv. Ert und Kurt, 1858, Ser. I, Bd. ii, p. 376, T. ii, figs. 7 and 8.

[4] Steinhardt. Die in preuss. Geschr. gef. Trilob. in Beitr. z. Naturk. Preussens. D. phys. ökonom. Gesellsch. z. Konigsb. 1874, p. 60, T. iv, fig. 17.

[5] Quart. Journ. Geol. Soc., vol. xiii (1857), p. 209, pl. vi, figs. 13 and 14.

Returning now to *Cyrtometopus* proper, we find it is succeeded by *Cheirurus* (*sens. str.*), the characters of which have been already given. The connecting link, so far as the pleuræ are concerned, is indicated by *Cyrto. Zembnitzki* (Eichw. sp.), in which the pleural groove has a slightly diagonal direction. In the characters of the glabella and head-shield, *Cyrto. Plautini* (Schmidt) shows some approach to *Cheirurus* (*sens. str.*), while *Ch. gelasinosus* (Portl. sp.) has not the marginal furrow communicating with the axal furrow, as it does in typical members of the subgenus *Cheirurus* (*sens. str.*). In the pygidia of *Cyrtometopus* and this subgenus there are striking points of similarity, for the anterior pair of pygidial pleuræ in many species of *Cheirurus* (*sens. str.*) is greatly enlarged and elongated so as to embrace the two posterior pairs, and the fourth pair is represented by a single median terminal piece.

With regard to the pygidium, it is noticeable that the species of *Cheirurus* (*sens. str.*) fall naturally into two groups when this portion alone of the body is considered, viz.: (1) the species with Cyrtometopian pygidia as just described, of which an example is *Ch. exsul* (Beyr.);[1] and (2) the species with three almost equal-sized pairs of short pleuræ, with a short single median or bifid piece representing the fourth pair. Such a condition exists commonly in *Ch. bimucronatus* (Murch. sp.), though many specimens from the Wenlock Limestone show a more or less marked enlargement of the first pair of pleuræ.

As regards these pygidial characters, the Russian species appear to belong entirely to the first group; in Bohemia the second group preponderates, as it does in Britain; while in Scandinavia the Russian type is in a majority. The period to which *Cheirurus* (*sens. str.*) is restricted extends from the middle part of the Ordovician to the upper part of the Silurian. Thus, while it commences during the reign of *Cyrtometopus*, it lives on after that subgenus has dwindled away or disappeared.

In Britain *Cheirurus* sg. is represented by *Ch. bimucronatus* (Murch. sp.)—with its three varieties, *bimucronatus* and *centralis* of Salter, and *acanthodes* (Marr and Nicholson)[2]—ranging from Bala to Ludlow beds; *Ch. gelasinosus* (Portl. sp.), from the limestone of the Chair of Kildare, on the same horizon probably as the Keisley Limestone, from which come also *Ch. glaber* (Angelin) and *Ch. keisleyensis* (Reed MS.). *Ch. cancrurus* (Salter), which occurs in the Kildare and Keisley limestones, may belong to this subgenus; but though the head figured by Salter[3] undoubtedly belongs to this subgenus, it is very doubtful whether it is rightly associated with the extremely atavistic pygidium on which the species was originally founded.

[1] A case of extreme specialization in this group is *Ch. subulatus* (Linnarsson), in which the pygidium has only two pairs of free pleuræ.

[2] Marr and Nicholson. The Stockdale Shales: Quart. Journ. Geol. Soc. 1888, vol. xl, p. 722, pl. xvi, figs. 7 and 8.

[3] Salter. Mon. Brit. Trilob.: Pal. Soc. 1864, p. 72, pl. v, fig. 16.

(*To be continued in our April Number.*)

REVIEWS.

I.—Catalogue of the Fossil Fishes in the British Museum (Natural History). By Arthur Smith Woodward, F.G.S., F.Z.S. Part III. 1895. 8vo, pp. xxxii and 544, with 18 Plates and 45 Illustrations in the text. Dulau & Co., London.

THE appearance of the third part of Mr. Smith Woodward's Catalogue of the Fossil Fishes in the British Museum will be welcome, not only to those who have occasion to busy themselves with the determination of genera and species, but to all who are interested in the classification of fishes in general, and in the fascinating problems connected with the evolution of this great class of Vertebrata. The time is surely now come for "biologists" to give some attention to palæontological as well as to embryological development, instead of looking upon fossil forms, as only too many seem to do, as something altogether outside the sphere of their work and interest.

This part, dealing mainly with the fishes ordinarily known as the "Lepidosteoid Ganoids," has taken four years in preparation; not too long a time when we consider the magnitude of the task of revising and rectifying such an enormous mass of genera and species, but also of tracing the true and natural affinities of forms and families, whose relationships have been in the past so obscured by the lingering influence of Agassiz, which has induced, and still induces, authors to place undue value upon characters of absolutely secondary importance, instead of boldly assigning the proper weight to those which are of a more deeply seated and genuinely morphological nature.

While much had been done by previous writers in the way of freeing Palæozoic Ichthyology from the "dermal character" incubus, Mr. Smith Woodward has had the work of elucidating the true morphological relations of the Mesozoic Semi-heterocercal Ganoids very much more to himself, for it cannot be said that recent attempts to systematize these fishes have been very successful. And the result is one of which neither the author nor the great national institution of which he is a prominent official need be ashamed.

The present part commences with the consideration of certain Mesozoic representatives of the Acipenseroidei, or, as the author prefers to call them, "Chondrostei," left over from last volume. Here, as previously indicated, Mr. Woodward includes the semi-heterocercal *Catopterus* and the abbreviate diphycercal *Belonorhynchus*, placing more weight upon the structure of the median fins than on the degree and manner of the caudal extension of the body-axis. The families treated of here are the Catopteridæ, Belonorhynchidæ, Chondrosteidæ, Acipenseridæ, and Polyodontidæ. Although Prof. von Zittel still "does not seem to see it," at least with the requisite clearness, it is gratifying to find that Mr. Woodward does not cease to support strongly the close relationship between the recent Acipenseroids and the extinct Palæoniscidæ and Platysomidæ, which was pointed out by the present writer in 1877.

With the dismissal of the Chondrostei the special interest of the present volume commences, as in the treatment of the typical Mesozoic Ganoids—be it remembered that "Ganoid" is now only a conventional term—a considerable amount of "redistribution of seats" takes place with regard to forms with which the general palæontologist is already familiar. As co-ordinate with Chondrostei, the author here deals with two further suborders of the Actinopterygii, viz. the Protospondyli and the Ætheospondyli, and part of a third, the Isospondyli.

Protospondyli.

The Protospondyli, abbreviate heterocercal fishes, with complex mandible, no interclavicular plates, and having the vertebral axis represented by a persistent notochord or by vertebræ which, at least in the caudal region, have the pleurocentra and hypocentra distinct and alternating, are, in fact, nearly the equivalent of what since Huxley's time have been called Lepidosteidæ or Lepidosteoidea, but with *Lepidosteus* left out and *Amia* included. For the disappearance of the "Amioidea" as a suborder I have long been prepared by the obvious similarity in cranial characters between *Amia* and such genera as *Lepidotus* and *Eugnathus*. And yet these have osseous, rhombic, brilliantly ganoid scales, while those of *Amia* are rounded, thin, and flexible—are, in fact, "cycloid" in the most Agassizian sense of the word. The condition of the squamation as an ordinal or subordinal, or even family characteristic, here receives its crowning blow, after having been utterly shaken by the occurrence of Palæoniscidæ with round, imbricating scales (*Trissolepis*, Fritsch, *Cryphiolepis*, Traquair); and a still further interesting case is afforded by Mr. Woodward's Semionotid genus *Æthiolepis*, in which the body-scales are rhombic, while those towards the tail are "cycloidal."

The families included by Mr. Woodward under Protospondyli are the Semionotidæ, Macrosemiidæ, Pycnodontidæ, Eugnathidæ, Amiadæ, and Pachycormidæ. In the first of these families we have deep-bodied "Stylodonts" like *Dapedius* included along with fusiform "Sphærodonts" like *Lepidotus*, for the mere shape of teeth is as of little classificatory importance as that of scales. Then as regards the Pycnodontidæ, Mr. Woodward has made a special and elaborate study of this remarkable family, bringing out many new and important structural facts, such as the fusion of the pterygo-palatine arcade with the base of the skull, etc. As regards the systematic position to which he has assigned these fishes, I have every reason personally to be gratified with his results. It is now many years ago since I imagined that I had successfully combated the idea of Egerton that the Platysomidæ were structurally related to the Pycnodontidæ, maintaining as I did that while the former were of Acipenseroid affinity, and indeed close to the Palæoniscidæ, the structure of the internal skeleton in the latter (Pycnodontidæ) pointed rather to their place being in "the great Lepidosteoid series of Ganoids" than in any other. Nevertheless, in his most recent systematic work Prof. von Zittel still maintains that the Pycnodontidæ are probably the descendants of the Platysomidæ, and asserts

that they differ principally in the dentition and in the condition of the jaws![1] It is to be hoped that Mr. Smith Woodward's emphatic declaration that the "Platysomidæ never make the faintest approach to the Pycnodontidæ in a single essential character," as well as the systematic position to which in the present work he has assigned the last-named family, will lead the distinguished palæontologist of Munich to reconsider a position which still retains us in the Agassiz-Egertonian period of palæichthyological science.

Ætheospondyli.

We have already seen that Mr. Woodward excludes *Lepidosteus* from the assemblage of semi-heterocercal rhombic-scaled fossil forms, with which it has been associated since the publication of Huxley's famous Essay on the Classification of the Devonian Fishes; and his reason is the structure of the vertebræ, which never, even in the caudal region, show separate and alternating pleurocentra and hypocentra. This character is shared also by *Aspidorhynchus*, though the vertebral centra are here ring-shaped or biconcave, instead of opisthocœlous as in *Lepidosteus*. The suborder of Ætheospondyli therefore includes the two families of Aspidorhynchidæ and Lepidosteidæ.

These two families are certainly closely related to the fishes brought together by Mr. Woodward under Protospondyli, by the complexity of the mandible and other characters, and it may indeed be a matter of opinion as to whether the condition of the vertebræ justifies their separation. The author himself states that "the recognition of this group is a confession of ignorance"—that is, ignorance of the immediate relationships of the two families therein included.

Isospondyli.

The third group after Chondrostei, which Mr. Woodward commences in this Part, is that of the Isospondyli, a term instituted by Professor Cope for a large and closely related series of recent "Teleostei," including the Clupeoids, Salmonoids, etc., and in which he also placed many of the Mesozoic "Ganoids," dealt with by our author in the previous pages of this volume. The Isospondyli are, however, distinguished from the Protospondyli and Ætheospondyli by the more simply constituted mandible, which, as in modern bony fishes generally, does not consist of more than two or three pieces, except perhaps in *Arapacina*. Only three families of Isospondyli are treated of in the present Part, namely, the Pholidophoridæ, Oligopleuridæ, and Leptolepidæ.

With the inclusion, already proposed by Cope, of fishes like *Pholidophorus* in one "suborder" with *Clupea* and *Salmo*, the "Ganoidei" of Agassiz may be said to have disappeared, and with them the "Palæichthyes" of Günther. Strange it is that after having been led so long an excursion by the illustrious founder of fossil ichthyology, our Ganoids should have got back pretty much to where they were—close to the Herrings!

[1] "Grundzüge der Palæontologie," München and Leipzig, 1895, p. 574.

Included in the "Addenda et Corrigenda" at the end of the Part is a notice of the hitherto problematic genus *Platysiagum*, Egerton, of the Lower Lias, which Mr. Woodward proposes to refer to the Palæoniscidæ. Certainly the osteology of the head of *Platysiagum* is palæoniscoid in the highest degree, and I should myself have referred it to this family twenty years ago had I not seen in the collection of the late Lord Enniskillen a specimen, now in the British Museum, in which the upper lobe of the tail seemed to be decidedly *non*-heterocercal. Mr. Woodward says, however, that the upper lobe of the tail is unknown, and my remembrance of the specimen is that the tail is so twisted that it is hard to know which is upper and which lower. At the same time I have many a time carefully examined the fish with the hope of finding myself mistaken in the orientation of its caudal lobes, but always with the same result. If Mr. Woodward's reading be correct, then the apparent anomaly of a fish with such a very palæoniscoid head and a non-heterocercal tail will be removed.

It would be impossible, within the limits usually allowed for a review of this kind, to enter into any more minute analysis of the contents of the volume now before me. Let me conclude by saying that the task of preparing this Part must have been a most arduous one, and that Mr. Woodward has performed it in a manner well deserving of the grateful and appreciative recognition of his fellow-workers in science.

Eight beautiful restored drawings of Mesozoic fishes are given in the text, which will surely be of more use to the textbook-makers than the antiquated Agassizian figures which down to the present day are so often copied and re-copied. As to the eighteen lithographic plates, it is sufficient to say that they, as well as the restored drawings, are from the accomplished pencil of Miss G. M. Woodward, and that, as might be expected, they occupy a place in the first rank of palæontographical work.

R. H. Traquair.

II.—Catalogue of the Mesozoic Plants in the Department of Geology, British Museum (Natural History). "The Wealden Flora. Part II: Gymnospermæ." 8vo, pp. 260. With Twenty Plates and Nine Figures in the Text. By A. C. Seward, M.A., F.G.S. London: Dulau & Co., 1895.

THE present volume completes Mr. Seward's excellent account of the fossil plants of the British Wealden formation. Unfortunately no remains of Angiosperms have, so far, been found in these beds, so the ascending series closes with the Coniferæ. The book, with the aid of the numerous and admirable plates (chiefly drawn by Miss Woodward), gives a clear picture of the *facies* of the Wealden Flora, and it would be difficult to speak too highly of the scientific judgment shown by the author in estimating the affinities of the various fossils.

Cycadean remains, or at least specimens most naturally referred to the Cycadaceæ, constitute an important feature of the Wealden

Flora. It is remarkable, however, to find how little evidence there is to prove that these various remains really belonged to plants like the Cycads of the present day. As the author says (p. 240): "We must remember that the so-called Cycadean fronds from Mesozoic rocks are nearly always found apart from the stems and reproductive structures, and we are still to a large extent in the dark as to the exact nature and structure of these extinct Cycadean plants."

In his introductory remarks Mr. Seward points out the frequent difficulty in distinguishing for certain between leaves of ferns and Cycadaceæ, and briefly discusses the evidence for the existence of Palæozoic members of the latter family. Some of the Carboniferous specimens, such as *Pterophyllum Fayoli*, Ren. and Zeill., have, he thinks, a strong claim to be regarded as Cycadean plants. Among the beautiful fronds from the Wealden figured in this book, many, and notably those referred to *Cycadites* and *Dioonites*, show a striking similarity to the leaves of recent genera. As regards *Cycadites*, the author indicates certain sources of error in determining whether the pinna has a single vein, the most critical point in determining the relation to the genus *Cycas*. No one can doubt the Cycadean *affinities* of the fronds and stems described here (with the exception of such doubtful genera as *Nilssonia* and *Anomozamites*). The difficulty is that fructifications are rare, and those which we know best (*Bennettites*) are quite different from any flowers of recent Cycads. Thus, we can never say for certain whether a given fossil, with Cycadean habit, really belonged to the family Cycadaceæ, in the comparatively narrow sense of recent Botany, or to the Bennettiteæ, a related, but perfectly distinct group.

The author recognizes scarcely any characteristic Cycadean fructifications among the specimens examined by him. So doubtful is he about forms hitherto referred to *Cycadeostrobus*, that he revives Sternberg's old genus *Conites* for their reception, thus avoiding any expression of opinion as to their true position. The only example of a true Cycadean fructification described is *Androstrobus Nathorstii*, sp. nov., which bears much resemblance to a male flower of this family, and in some specimens shows with great clearness the scars of numerous pollen-sacs on the lower surface of the scales.

Among stems of Cycadean habit, a new species of *Fittonia* is described, with the leaf-bases remarkably well preserved. The author regards certain Wealden stems formerly referred to *Dracæna* as being much more probably Cycadean, and points out their resemblance to some species of *Zamia*. He finds no evidence for the existence of Monocotyledons in the English Wealden.

A full account is given of that most interesting of all Mesozoic genera, *Bennettites*, which the author identifies with *Williamsonia*. The internal structure of the fructification of this extraordinary plant, which, to a certain extent, combines Cycadean with Angiospermous characters, is now well known owing to the classical researches of Carruthers and Solms-Laubach, and, more recently, those of Lignier. The author describes some very interesting specimens from the Wealden, which he refers to another species, *B. Carruthersii*.

The internal structure is not preserved, but the habit of the fruit is excellently shown, as the plates testify. The author's careful comparison with the more completely known species leaves no doubt as to the essential identity of structure.

Mr. Seward considers that we are still without any very satisfactory evidence as to the nature of the male inflorescence, all the well-investigated specimens being apparently female.

The author founds a new genus (*Withamia*) for a remarkable fossil, much resembling the *Cycadorachis* of Saporta. He shows that there is no real similarity to the rachis of any Cycad, and defines the new genus as follows: "A woody axis bearing two rows of spiny appendages, in the axils of which are borne flat leaf-like appendages." There is at present no clue to the affinities; the comparison with *Phyllocladus* is perhaps as instructive as any.

Mr. Seward says that, "as a general rule, fossil Conifers are perhaps the most unsatisfactory plants with which the palæobotanist has to deal." Consequently he treats the fossils referred to this order with special caution, though he has some beautiful specimens to record. So far as the remains justify any definite conclusion, it would appear that the principal tribes of the order were already developed in the Wealden epoch; Araucarieæ, Abietineæ, Taxodineæ, Cupressineæ, and Podocarpeæ all have fairly accredited representatives. A new species, *Pinites Solmsi*, is founded on excellent fertile specimens, which strongly suggest the recent genus, though neither the exact morphology of the cone nor the insertion of the leaves can be determined with certainty.

Brachyphyllum spinosum, sp. nov., with its great rhomboidal leaf-scars and spinose branches, is a most striking plant, which we would gladly know more about.

In his concluding remarks the author says (p. 240): "Looking at the Wealden plants collectively, we notice a very striking agreement with the flora of the underlying Jurassic strata, and it would be difficult to point to any well-marked or essential difference between the plant-life of the two periods. The evidence of palæobotany certainly favours the inclusion of the Wealden rocks in the Jurassic series."

Both the author and the Museum are to be warmly congratulated on the completion of this book. If all writers on fossil botany had shown the same sound and cautious judgment which characterizes Mr. Seward's work, the subject would now be in a much more advanced position than it is. D. H. S.

III.—Memoirs of the Geological Survey of the United Kingdom. "The Jurassic Rocks of Britain. Vol. V: The Middle and Upper Oolitic Rocks of England (Yorkshire excepted)." By Horace B. Woodward, F.G.S. 8vo, pp. xiv and 499; 145 Figures and Map. London: Dulau & Co., 1895.

THE previous volumes of this important work have from time to time been noticed in the Geological Magazine, and we now have to congratulate Mr. Woodward on the appearance of the

fifth volume, which completes the Memoir on the Jurassic Rocks of England. The Survey, however, promise us a concluding volume, relating to the Jurassic Rocks of Scotland and Ireland, after those of Scotland have been mapped in detail.

As in the previous volumes, Mr. Woodward avails himself largely of the published observations of other workers in the same field, and he has also received considerable assistance at various times from local geologists. All these are duly acknowledged. The fossils collected during the progress of his work have been named by Messrs. Sharman and Newton, whilst Mr. Teall has examined and described microscopic sections of the rocks.

The Upper Jurassic (Middle and Upper Oolites) in this country is essentially a pelolithic deposit, which in the East Midlands is scarcely relieved by any shelly limestones; whilst in the West Midland and Southern Counties two great calcareous deposits (Corallian and Portlandian), each supported on an arenaceous base, serve to relieve the monotony of these extensive clay formations.

As regards the uppermost limits of the system, Mr. Woodward observes that the general relationship between the Purbeck and Wealden strata has led many geologists to group them together. He also considers that the local evidence would not justify us in parting them, and it is only on wider grounds that the division between Jurassic and Cretaceous is taken between the two. Thus, he says, "We may be content to allow the claims of general convenience and of palæontological succession established in Europe to rule the limits of our principal chronological systems."

However, he goes on to say that as regards the several subdivisions the case is different; such formations must be based on their stratigraphical features, and he justly insists on the importance of maintaining the original divisions of our strata as taken from the typical localities. The following general arrangement is adopted:—

Upper Oolites.	Purbeckian	Upper Purbeck Beds Middle Purbeck Beds Lower Purbeck Beds	Spilsby Sandstone.
	Portlandian	Upper Portland Beds. Lower Portland Beds and Hartwell Clay.	
	Kimeridgian.	Kimeridge Clay.	
Middle Oolites.	Corallian	Coral Rag and Coralline Oolite Calcareous Grit	Upware Limestone and Ampthill Clay.
	Oxfordian	Oxford Clay. Kellaways Beds.	

Oxfordian.—The author recognizes three palæontological horizons in descending order, viz.: *Ammonites cordatus, Am. ornatus* (perhaps a generalized term), and *Am. Calloviensis.* He gives a useful summary, and many details are now for the first time published. As a rule, Oxfordian beds, south of the Humber, do not afford many prominent features, so that their lithology and palæontology must be worked out, for the most part, in brickyards, well-sections, and

railway-cuttings. It was a grand time for collectors when the *ornatus*-clays of Christian Malford were cut through in making the Great Western Railway.

For many years subsequently little was added to our knowledge of the Oxford Clay. But latterly the subject has again attracted attention. The author and his colleagues, for instance, have carefully investigated the strata at Kellaways itself. Moreover, the well-sinking at Swindon added largely to our knowledge of Oxfordian beds. This operation was watched and reported upon by the author and Mr. E. T. Newton, with very complete results. To the *cordatus*-zone was assigned 288 ft., to the *ornatus*-zone 220 ft., and to the *Calloviensis*-zone 62 ft. The evidence agrees with that furnished in other localities, that the Kellaways Rock is but an irregular and sandy, impersistent bed towards the base of the Oxford Clay, locally fossiliferous. The tendency to form great doggers on this horizon in certain localities is well exhibited in a railway-cutting near Cirencester. The total thickness assigned to the Oxfordian beds at Swindon is 572 ft., being considerably in excess of Prof. Prestwich's estimate of 300 ft. at Oxford.

Passing on to the East Midlands, Mr. Woodward has had the advantage of being able to consult Judd's "Geology of Rutland," as well as the works of the late Thos. Roberts, who possessed a most accurate and extensive knowledge of the fossils of the Upper Jurassic clays. Several other members of the Survey have also contributed of late years to our knowledge of Oxfordian beds in Lincolnshire.

Corallian.—It is not a little singular that the term "Corallian," which, strictly speaking, is of French origin, should in some quarters be falling into disuse in that country, and that "Rauracien" and "Sequanien" more or less occupy its place. However, in England the term is exceedingly applicable for the variable series of strata that occur between the Oxford and Kimeridge Clays. Messrs. Blake and Hudleston supplemented the work of the older writers on this formation, and Mr. Woodward has in many cases adopted their local stratigraphical divisions. His general grouping is as follows:—

Upper Corallian	Upper Calcareous Grit, Upper Coral Rag and Ironstone, Coral Rag, and Coralline Oolite	Zone of *Ammonites plicatilis*.
Lower Corallian	Lower Calcareous Grit	Zone of *Ammonites perarmatus*.

This arrangement differs from the original Survey mapping of the strata from Dorsetshire to Berkshire, where a tripartite division was maintained, the highest beds being called "Upper Calcareous Grit"—a name borrowed from Yorkshire. Certainly, the highest Corallian beds in Dorsetshire, and to a less extent in Wiltshire, present marked peculiarities, such as extensive ferrugination, in some cases amounting to an iron-ore. Moreover, the fauna is peculiar, though this is to some extent due to physical differences. Hence these beds are in a certain sense Kimeridgian, and it is just

possible that the Abbotsbury Ironstone is on the horizon of the "Pterocerian" beds, though the *Pteroceras*-fauna is wanting in this country.

There can be no doubt that the Corallian series as developed at Weymouth and Osmington presents many attractions, both to the stratigraphist and the collector. It is so varied, so accessible, and so fossiliferous, and there are such excellent sections on the coast, that the geologist is invited, as it were, to bring out his hammer, his compass, and his tape, and try what he can make of the exposures. The very fact of the whole series occurring in duplicate, *i.e.* on either side of the Weymouth anticline, renders the study of these rocks all the more interesting. Mr. Woodward's measurements differ somewhat from those of Blake and Hudleston, but in all other respects he confirms their work. An ample list of fossils from the Corallian rocks near Weymouth, including the Abbotsbury iron-ore, concludes this part of the subject.

Full details of the Corallian beds are given as they are traced towards the north-east, until their final disappearance in a distinct lithological form in Oxfordshire. The subject of the Ampthill Clay may detain us for a moment. Although this argillaceous equivalent of Corallian beds was first indicated by Prof. Seeley, it is to the labours of the late Thomas Roberts that we owe most of our knowledge of its contents. The subject, like that of all Fen clays, is a difficult one, and distasteful to many; but Roberts' singular knowledge of Upper Jurassic fossils enabled him to grapple with it successfully, and the readers of the Quarterly Journal may remember that he ventured to map this Corallian clay in Cambridgeshire and Lincolnshire.

Kimeridge Clay (*Kimeridgian*).—The term "Kimeridge strata," we are told, was employed in 1812 by Thomas Webster, and in 1818 the term "Kimeridge Clay" was used by Buckland. In England the beds of this age are mainly clays. When we bear in mind that this formation varies in thickness from 1200 feet in the great Kimeridgian trough of the south of England to less than 100 feet in the neighbourhood of Oxford, and that it includes a variety of zones recognized on the Continent, some based on Cephalopoda and others on different orders of Mollusca, it must be admitted that an author in Mr. Woodward's situation has unusual difficulties to contend with. There is even a further trouble, viz. how to distinguish between Kimeridgian clays and Portlandian clays, in cases such as Hartwell, where no lithological indications of a separation between the two present themselves. To show such a Portlandian clay on a map would be next to impossible: indeed, the only place in England where a palpable Portlandian clay is clearly separated from the Kimeridge Clay by beds whose fauna and lithology are distinct, occurs at Swindon.

Agreeing with Prof. Blake that there is no need in this country to divide the Kimeridge Clay into more than two zones for general stratigraphical purposes, Mr. Woodward adopts the following arrangement (see table on page 133):—

It has generally been considered that the Lower Kimeridge of Dorsetshire represents in the main the "Virgulien" of foreign authors, and casts of *Ex. virgula* are said to have been found as low down as the Abbotsbury iron-ore. But Mr. Woodward finds this fossil, together with *Am. longispinus*, also in the Upper beds. These latter, between 600 and 700 feet thick in some places, are exceptionally developed in Kimeridge Bay and throughout the Isle of Purbeck, where the dark bituminous and paper shales of Chapman's Pool, etc., charged with *Lucina minuscula* and *Discina latissima*, are of immense thickness. The most curious feature of the whole is that, although there is a complete sequence between these clays and the Portland beds of St. Albans Head, yet the so-called Middle Portlandian fauna of Swindon and Hartwell has not yet been discovered in that locality.

KIMERIDGE CLAY.

ZONES.	SUBZONES.
Am. biplex.	*Discina latissima.*
	Exogyra virgula.
Am. alternans.	*Ostrea deltoidea.*

Away from the coast we are mainly dependent upon brickyards, etc., for our knowledge of the Kimeridge Clay, so that the divisions cannot be made out with certainty in all places. Of course it is obvious that the fauna of Hartwell, for instance, differs entirely from that of Ringstead Bay, although for purposes of mapping both are included in the Kimeridge Clay. We quite agree with the author that "it is not possible to be consistent in all our dealings with these formations without detailed and long-continued hunting for fossils." Even then much remains to be explained.

In the East Midlands the observations of Blake have been supplemented by those of Roberts, and it is to the palæontological researches of these writers that we are indebted for most of our knowledge of the Kimeridge Clay in the counties of Cambridge, Norfolk, and Lincoln. In the Isle of Ely, Roberts recognized 15 ft. of Upper Kimeridge with *Discina latissima* and *Exogyra virgula*, and 80 ft. of Lower Kimeridge with *Ammonites alternans*, *Astarte supracorallina*, and *Ostrea deltoidea*. It is noteworthy that here *Exogyra virgula* is regarded as an Upper Kimeridge form.

Portland Beds (*Portlandian*).—Declining to accept the term "Bolonian" for any of these beds, Mr. Woodward adopts the following grouping:—

Upper Portland Beds	Portland, Tisbury, and Swindon Stones.
Lower Portland Beds	Portland Sand, Swindon and Hartwell Clays.

He further remarks that the zones of the Portland beds most generally adopted are those of *Am. giganteus* and *Am. gigas*, the

leading fossils of each, some of them being taken to indicate subzones, being mentioned. Owing to the earlier incoming of "Portlandian conditions" in some parts of the Continent, we consider that the beds so identified are partially homotaxial rather than synchronous; this is particularly well seen in the case of certain *Trigoniæ* and other characteristic shells of the more estuarine beds. The zone of *Am. gigas* in this country is a conventional one, and if we must have an Ammonite to represent the *Astarte Sæmanni*-beds of Swindon, *Am. pectinatus* would seem more appropriate.

The local details of the Portland beds vary greatly in the several districts; yet, notwithstanding certain differences in lateral development, these beds have been correlated by Prof. Blake. The building stones are not always on the same horizon; the main building stones of the Vale of Wardour, for instance, occupying a lower position than those of the Isle of Portland. The Isle of Purbeck presents us with the most massive development of Portland rocks, but they are less interesting from a palæontological point of view than those of Portland Isle and the Vale of Wardour, whilst the Upper Portland beds of Swindon are quite abnormal in their development. Again, a very distinct type of beds, smaller in volume but often richly fossiliferous, occurs in Buckinghamshire. It has always seemed to us that there are evidences of considerable wasting of Portland beds, very noticeable in the Isle of Purbeck and in the Vale of Wardour, before the Purbeck strata were laid down: these evidences Mr. Woodward seems inclined to minimize.

Purbeck Beds (*Purbeckian*).—These attracted the notice of geologists at an early period, so that there is a considerable literature on the subject. The present volume supplies us with a useful summary, besides including many details now for the first time published. The author, no doubt, rejoices that at length he is free from the necessity of recognizing Ammonite-zones, though, as he remarks, "our Purbeck strata may be equivalent to beds on the Continent with a marine fauna and grouped in the zone of *Am. transitorius*." In the Alpine region we may regard them as corresponding in the main with the Upper Tithonian, whilst in the north-east of England "they may be in part equivalent to the zone of *Belemnites lateralis* of the Spilsby Sandstone and Speeton beds." This latter correlation was indicated by Pavlow, and seems a very reasonable supposition.

The chief points of a controversial character in connection with the Purbecks are: (1) the exact nature of their relationship to the underlying Portlands, and (2) where to draw the line between Jurassic and Cretaceous in the great fresh-water series, which, in this country, occupies an episodal interval between the marine beds of these two great systems. On this latter point the correlation of the Purbeck beds of the English Channel with those of other localities opens up some interesting questions. This is especially the case as regards the Vale of Wardour, where Messrs. Woodward and Strahan demur to the conclusions of Messrs. Andrews and Jukes-Browne to the effect that strata hitherto regarded as Wealden should be classed with the Upper Purbeck.

Not the least interesting portion of the volume is that relating to the "underground" Oolitic rocks, whose existence has been indicated of late years over a considerable area by boring operations. In the map forming the frontispiece is shown the area occupied by Oolitic rocks which are directly covered by Neocomian or Cretaceous beds, whilst certain areas are left uncoloured where it is probable that Palæozoic rocks directly underlie the post-Jurassic strata. If the author be correct in his delineations, the area of "underground" Oolitic rocks fully equals, if it does not exceed, the outcrop. The Purbeck beds of Battle are indicated, we presume, on the map by three little inliers, whose total outcrop must be very small. Many diagrammatic sections also illustrate this portion of the work.

As regards illustrations generally, this volume is not more fortunate than its predecessors in the series. The figures of fossils are numerous, and, on the whole, fairly characteristic, but in some cases they are indistinctly printed, and the same may be said of many of the sections. But the rendering of several of the photographs is positively disastrous: such cuts as Figs. 80, 92, and 102 are mere smudges, and there are others almost as bad.[1] On the other hand, the "Fossil elephant" at Portisham comes out pretty well. We may feel sure that these shortcomings are not due to any fault on the part of the photographers; can it be that such unhappy results are owing to the parsimony of the "Lords Commissioners of Her Majesty's Treasury"?

In all other respects the volume is most satisfactory. The scenery, economic products, and water supply of the Middle and Upper Oolites come in for their share of attention. Exhaustive lists of fossils are given, and the promised bibliography of the Jurassic rocks of the British Isles is now published. Nothing has been omitted on the part of Mr. Woodward and his colleagues to render the "Jurassic Rocks of Great Britain" a work of the highest utility and importance. The author of this latest volume is especially to be congratulated on the accuracy of his observations, on the impartiality of his decisions, and on the many proofs which the work affords that he possesses a grasp of the subject such as constant application in the study and long experience in the field alone can give.

IV.—Fishes, Living and Fossil: an Outline of their Forms and Probable Relationships. By Bashford Dean, Ph.D. Pp. xiv, 300, with 344 Woodcuts and Frontispiece. New York and London: Macmillan & Co., 1895.

PALÆONTOLOGY is gradually beginning to occupy a prominent position in biological textbooks. Zoologists and botanists of the rising school are more and more convinced of the impossibility of arriving at the fundamental principles of the world of life merely by reference to its surviving representatives. To Dr. Bashford Dean, however, we are probably indebted for the boldest acknow-

[1] The Stationery Office has reprinted Figs. 80 and 92.—*Reviewer.*

ledgment that has hitherto been made of the prime importance of the succession of life in geological time in determining questions both of morphology and of classification. We have before us his new volume on fishes, just issued in the Columbia University Biological Series, which not merely associates the living and fossil forms in its title, but is permeated throughout with a philosophy which no amount of study of existing fishes would suggest. This is as it should be, and we are delighted to welcome a departure which is likely to be followed by many similar essays.

Ichthyology, of course, does not strictly fall within the province of our pages, but we are especially concerned with the palæontological basis on which it must rest; and readers of the GEOLOGICAL MAGAZINE will find many features of great interest in this latest contribution from the University, which the late Dr. Newberry's writings have made famous in the annals of Geology and Palæontology. We propose to review the work from the palæontological point of view, referring more particularly to the original matter which Dr. Dean himself has added to his summary of previous research.

A brief introductory chapter on the adaptation of fishes to life in a watery medium is followed by a table of classification closely resembling that adopted in the British Museum Catalogue of Fossil Fishes. Next comes a second table showing the distribution of fishes in geological time, mainly based on Zittel's well-known "Handbuch." In this, however, a few small errors have escaped correction, notably the extension backwards of the Acipenseroids and Lepidosteoids to the Upper Silurian, the Clupeoids to the Trias, and *Pristiophorus* to the Trias and Permian. Nor are any undoubted Arthrodira known above the lowest Carboniferous. In fact, in some of these respects the table does not agree with statements in the text further on.

After these preliminaries Dr. Dean considers the evolution of the structures characteristic of fishes, and again makes numerous references to the facts of palæontology in their bearing on the subject. This chapter is for the most part admirable and well up to date in every respect, besides containing important new facts concerning the fin-structures of the primitive Carboniferous shark, *Cladoselache*, to our knowledge of which Dr. Dean has already made several contributions. We have only minor faults to find with the author's treatment of the subject. The researches of Jaekel, for instance, now make it doubtful whether the Permian Pleuracanths had more than five branchial arches (p. 16). Fig. 33 (p. 39) represents a dorsal fin-spine of the Carboniferous *Lepracanthus*, not *Hybodus* as labelled. The spine marked R in the fin of *Parexus* (fig. 51) is a dermal structure not homologous with the cartilages similarly lettered in the accompanying figures; but here Dr. Dean appears to frame an hypothesis that cartilages are clustered in its interior. Finally, we have never observed the pineal foramen in *Ctenodus* and *Palædaphus* noticed on p. 55.

The Lampreys and their allies form the subject of chapter iii.

Here Dr. Dean definitely places the remarkable Devonian fossil *Palæospondylus Gunni*, which "seems undoubtedly a Lamprey." The Ostracoderms are also provisionally associated with these primitive vertebrate animals, and they are arranged in accordance with the British Museum Catalogue. Dr. Dean points out the close resemblance between the labial plates of *Pterichthys* and the form of the sides of the mouth in the Lamprey. He also makes the interesting announcement that from personal observation he considers the so-called paired fins of *Palæaspis* (Claypole) are "merely Elasmobranchian (Chimæroid?) spines, in crushed condition, accidentally associated with the head region of the fossil." The figures illustrating this section, however, are less satisfactory than they might have been. The restoration of *Pteraspis* does not show the strongly convex ventral shield; and the figures of *Pterichthys* do not exhibit the correct position of the labial plates or the large proportions of the caudal fin. There is also a misapprehension in the statement (p. 69) that the paired appendages of *Pterichthys* "are now known to be nothing more than the lateral head angles produced and specialized (*i.e.* jointed for locomotion)." The appendages in question never have any connection with the head-shield, but are fixed to a thickened part of the body-armour.

The sharks, as might be expected, are very fully treated from the palæontological aspect in chapter iv. The most important perhaps of all Palæozoic sharks, *Cladoselache*, from the Lower Carboniferous of Ohio, occupies the foremost place. All the known species of this shark are of relatively small size, varying in length from two to six feet. In general aspect it is much like a modern shark, with a small horizontal keel on each side at the base of the tail. In many ways, on the other hand, it is the most generalized of known sharks:—"Its paired fins are but the remnants of the lateral fold, serving as balancers; the tail, curiously specialized, is widely heterocercal, its hinder web lacking supports in the upper lobe; the vertebral axis is notochordal; and the writer now finds that an exceedingly simple condition existed in the neural and hæmal arches; they prove to be of moderate size and thickness, each a tapering rod of cartilage, forked at its base; each body segment contains a single neural and hæmal spine, closely alike in size. Unlike modern sharks, *Cladoselache* was without claspers: its eggs must have been fertilized after their deposition, as in the majority of fishes other than Elasmobranchs. The gill openings, at least seven (probably nine) in number, appear, as in the restoration, to have been shielded anteriorly by a dilated dermal flap. A spiracle was probably present. The jaws were slender, and apparently hyostylic; the teeth are of the pattern of shagreen denticles, but occur in clusters ('*Cladodus*'). The mouth was terminal in its position. The nasal capsule was apparently not connected with the mouth by a dermal flap. The eye was protected by several rings of rectangular plates, clearly shagreen-like in character. The integument was finely studded with minute

lozenge-shaped denticles, and was everywhere lacking in membrane-bones. The lateral line retained its groove-like character."

Cladoselache is the type of a new order, Pleuropterygii, and that of Acanthodii immediately follows in Dr. Dean's classification. We do not agree with this association, but there is perhaps much reason for differences of opinion in the present state of knowledge of the endoskeleton of all these early Palæozoic fishes. We are, however, certain that in his amended restoration of *Acanthodes*, Dr. Dean has made the eye very much too small; and there is another unfortunate mistake in his emendation of Fritsch's figure of *Pleuracanthus*, where a large coprolite (specially noted by Fritsch) is made to do duty for the pelvic cartilage. From an examination of the original specimen, we are also convinced that the so-called "dermal bones of the head roof of *Pleuracanthus*," copied from Davis in fig. 90B, are merely an imaginative reconstruction of an indeterminable fossil, which may or may not be part of an Elasmobranch skeleton. The general results of modern research, however, are admirably summarized in the letterpress, and the general conclusion is arrived at that "of all known stems that of the shark is most nearly ancestral in the line of jaw-bearing vertebrates."

The chapter on Chimæroids is naturally brief, and contains no new matter; but there are two original restorations of the head of *Squaloraja* and *Myriacanthus* to show the position of the peculiar rostral spine. The fossil genera referred to the Dipnoi and the doubtfully distinct Arthrodira, are treated more from personal observation. There is a good new restoration of the Devonian Dipnoan *Dipterus*, another of *Phaneropleuron*; a modified restoration of *Coccosteus*, in which the upper dorsal fin-supports are made to form a slight lobe, while the tail is nearly diphycercal; an entirely new restoration of *Dinichthys* much on the plan of *Coccosteus*, and a page of sketches of the mandible of Arthrodira, from the Cleveland Shale of Ohio. The latter are particularly interesting as showing the remarkably varied modifications of the teeth in these old armoured fishes. *Mylostoma*, for instance, with loose grinding teeth, is now definitely proved to belong to this group, although most of the genera have either conical or shear-like teeth. On the whole Dr. Dean is inclined to believe that the Arthrodira differed more widely from the typical Dipnoi than did these from the ancient sharks. They may, he thinks, be ultimately regarded as worthy of rank as a class.

The Teleostomi seem to be less satisfactorily treated than the previous groups. This is probably due to their great numbers and innumerable variations. They are subdivided into Crossopterygii and Actinopterygii, and Dr. Dean admits that the former may have been ancestral, not only to the latter, but also to the Dipnoi. A slightly amended restoration of *Holoptychius* is given, and there is a copy of Whiteaves' restoration of *Eusthenopteron*; but the other two figures illustrating the more primitive Crossopterygians are unfortunately Pander's restorations of *Gyroptychius* and *Osteolepis*, which modern researches have proved to be in many respects

inaccurate. There is also the first attempt at a restoration of *Cœlacanthus*, based on the fine specimens from the Coal-measures of Ohio; and another less satisfactory restoration is given of *Diplurus*, from the Trias of New Jersey. The Actinopterygians are merely subdivided into the Chondrosteans (Ganoids) and the Teleocephali (Teleosts), an arrangement scarcely adequate to our present knowledge of the subject. Of Mesozoic Actinopterygians good figures are copied from Traquair and Zittel, but the series is spoiled by the insertion of three very erroneous early attempts by Agassiz to show the principal features of *Rhabdolepis macropterus*, *Caturus furcatus*, and *Leptolepis sprattiformis*. The last two figures, as also those by Pander, are wrongly ascribed to the writer of this review. So little is known of the ancestry of the groups of true bony fishes, that Dr. Dean makes little or no reference to the fossil forms, merely attempting a theoretical diagram to illustrate their evolution. The final chapter of the book, however, shows that the extinct forms must be relied upon almost entirely to determine this evolution; for, in treating of the development of fishes, the author particularly emphasizes the fact that their embryology seems to afford scarcely any clue to the solution of problems of descent. The latest results from the study of the embryos of many groups are all, indeed, very inconclusive, and most of them are not even suggestive. As Dr. Dean remarks, "adaptive characters have entered so largely into the plan of the development of fishes, that they obscure many of the features which might otherwise be made of value for comparison."

The work concludes with an extremely useful and carefully prepared bibliography, a list of derivations of proper names, and a number of diagrams and tables of fish anatomy, to show at a glance the differences between one group and another. It is a volume indispensable to all who desire a general acquaintance with the subject of which it treats, and students are much indebted to the author for having furnished them for the first time with a thoroughly up-to-date handbook.

A. Smith Woodward.

REPORTS AND PROCEEDINGS.

Geological Society of London.

February 5th, 1896.—Dr. Henry Woodward, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Morte Slates and Associated Beds in North Devon and West Somerset.—Part I." By Henry Hicks, M.D., F.R.S., F.G.S.

In a paper read before the Society in 1890 the author stated that he had found the Morte Slates to be fossiliferous, and had come to the conclusion that they were the oldest rocks in the North Devon area, and had been thrust over much newer rocks, producing a deceptive appearance of conformity; and that there was not a continuous upward succession in the rocks from the Bristol Channel

to the neighbourhood of Barnstaple. Since that paper was read, the author has obtained much additional evidence bearing on the succession, which is given in the present paper so far as the position and age of the Morte Slates in the Ilfracombe area are concerned.

The author describes the lithological characters and fossil contents of the Morte Slates, and their relationship to the Pickwell Down Sandstones and Ilfracombe Beds, treating of the development of the rocks in four areas, viz.: Morthoe and Woolacombe to Bittadon; Rockham Bay, Bull Point, Lee, and Slade; Mullacott, Shelfin, and Ilfracombe; and Woolscott Barton, Smithson, and Berry Down. The great abundance of detrital mica in the Ilfracombe Beds and Pickwell Down group, and its almost entire absence from the Morte Slates, are noticed. The faulted junction of the Pickwell Down Sandstones and Morte Slates is described, and it is held that the faulting has not thrust older beds over newer, as maintained by Jukes, but that the order of succession is the original one, whereas the overthrust fault separates the Morte Slates from the now underlying though newer Ilfracombe Beds, which often dip away from the Morte Slates, while different members of the Ilfracombe series abut against the Morte Slates, so that the latter form a complex group of older rocks bounded on either side by newer strata. The author states that the fossils found in the Morte Slates belong to several horizons, some probably as low in position as the base of the Silurian (Upper Silurian of the Geological Surveyors), while none of the beds of the series appear to be newer than the older Devonian. In some places newer rocks may occur amongst them as the result of faulting or unconformity, but not in order of succession.

A description of the species found in the Slates is appended to the paper.

2. "Evidences of Glacial Action in Australia in Permo-Carboniferous Time." By Prof. T. W. Edgeworth David, B.A., F.G.S.

The author, after summarizing the work of previous observers, gives an account of recent observations made by himself.

In Hallett's Cove, near Adelaide, the pre-Cambrian rocks are strongly glaciated, striæ being seen when the overlying glacial beds are removed, as sharply cut as though caused by recent glacial action, and trending nearly north and south, the ice having come from the south. The overlying glacial beds are in places fairly stratified, while parts contain abundance of well-striated boulders: these beds are from 23 to over 100 feet thick. Proofs were obtained that in this case the glaciation occurred in an age intermediate between Miocene and pre-Cambrian, and probably did not antedate the close of the Palæozoic period.

In Wild Duck Creek, near Heathcote, Lower Silurian (Ordovician) beds exhibit strongly-grooved, polished surfaces, the grooves being from S. 5° E. to N. 5° W., the ice probably having come from the south. They are succeeded by Permo-Carboniferous glacial beds, consisting chiefly of mudstones with well-glaciated boulders.

At Bacchus Marsh, Ordovician beds are also well striated and

polished, and more or less *moutonnée*. Here also the ice came from a southerly point. These beds are succeeded by Permo-Carboniferous glacial beds having an approximate thickness of at least 2000 feet, consisting of mudstones with well-glaciated boulders.

It is extremely probable that the glacial beds of Bacchus Marsh, Wild Duck Creek, and Springhurst in Victoria were of homotaxial if not contemporaneous origin, and they may probably be correlated with the glacial conglomerates at Mount Reid in Tasmania, these correlations being mainly based on lithological evidence. The evidence for the correlation of the Bacchus Marsh glacial beds with the erratic-bearing Permo-Carboniferous mudstones of Maria Island, One Tree Point, and Bruni Island in Tasmania, of Maitland, Branxton, and Grasstree in N.S. Wales, and of the Bower River coalfields in Queensland, is that the genus *Gangamopteris* is distributed somewhat abundantly throughout the formations in all these localities.

This glaciation was probably homotaxial with that of the period of the Dwyka Conglomerate and Ecca Beds of Southern Africa, and of the Talchir Group of the Salt Range of India, the Boulder Beds in Western Rajputana, and the Panjáh Conglomerates of Kashmir. In the case of Southern Africa and India, as in that of Australia, the general direction in which the ice moved appears to have been from south to north. In the Bacchus Marsh beds there are at least nine or ten distinct boulder-beds separated by sandstones and conglomerates; this may possibly indicate a sequence of glacial periods separated by milder interglacial periods. The glacial conditions in Australia may have been prolonged into early Mesozoic times, as indicated by the Mesozoic facies of certain plants in the uppermost glacial beds of Bacchus Marsh.

Royal Physical Society of Edinburgh.

February 19th, 1896.—Prof. Struthers, M.D., LL.D., in the Chair.

Mr. J. S. Flett, M.B., B.Sc., read a paper on his "Discovery in Orkney of the John o' Groat's Horizon of the Old Red Sandstone." The strata examined and described in this paper were in the parish of Deerness, on the mainland of Orkney, and from them he had obtained *Microbrachius Dicki* (Peach), *Dipterus macropterus*, Traq., and *Tristichopterus alatus*, Egert., species which had hitherto been found only in the John o' Groat's beds in the north-east of Caithness. The identification of these fishes was confirmed by Dr. Traquair, to whom Mr. Flett had submitted his specimens for examination.

Geologists' Association.—At the Annual Meeting of the Association, held on Feb. 7th, 1896, Mr. E. T. Newton, F.R.S., was elected President, and Mr. H. W. Monckton was elected Excursion Secretary in the room of Mr. T. Leighton, who for a number of years has filled that arduous office with great success. The retiring President, Lieut.-General C. A. McMahon, read an address on "Some Structural Characteristics of the Granite of the N.W. Himalayas," illustrated by numerous lantern-slides.

CORRESPONDENCE.

HEIGHTS OF CHALK.

Sir,—I am glad that Mr. Lamplugh has corrected me as to the greatest height of the northern Chalk. Garrowby Hill seems to lie near the edge of the elevated area; in going over the sheets of the Ordnance Map I had not noticed its exceptional height; I have never been in that part of the district.

Besides this correction another has to be made. I wrote: "Mr. Deeley tells us that Chalk-drift is found in Leicestershire up to 800 feet." But his actual words are:[1] "At Tilton, one of the highest points in East Leicestershire"; he makes no definite statement of height. The ground at Tilton rises to 700 feet; the figures 800 are a slip of my own memory. So I have not only made an incorrect statement, but made Mr. Deeley seem responsible for it.

January 24th, 1896. E. Hill.

ON THE APPENDAGES OF TRILOBITES.

Sir,—At the present time, when the important researches on the structure of Trilobites, recorded of late years, have highly excited the interest of palæontologists upon this subject, I hope you will permit me to call attention to an observation on the antennæ of these fossils made by Linnæus upwards a hundred and forty years ago, and, as far as I know, never referred to. In the Proceedings of the Swedish Academy of Science ("Svenska Vetenskaps-academiens Handlingar"), vol. xx, issued in 1759, Linnæus communicated an article entitled "Petrificatet Entomolithus paradoxus, sådant, som det finnes uti Hans Excellence Riks-Rådets Högoälborne Herr Grefve C. G. Tessins Samling." A specimen of *Parabolina spinulosa*, Wahlenb., is there figured, tab. i, fig. 1, showing one pair of antennæ at their true place; and from the accompanying description it appears that the author attached due importance to the presence of these organs. His words relative to them (pp. 21, 22) run thus, translated into English: "Fig. 1 is one of the clearest specimens I ever saw among so many thousands. Most remarkable in this specimen are the antennæ in the front, which I never saw in any other example, and which clearly prove this fossil to belong to the insects" (=Arthropoda). The specimen in question had been found by Dr. Tidström, and was shown to Linnæus, as seen above, by the Count C. G. Tessin. This reference to an old observation can by no means abate anything of the value of the brilliant discoveries of our days, but justice demands this discovery of Linnæus to be rescued from the oblivion into which it seems to have sunk.

Sv. Leonk. Törnquist.

Lund (Sweden), *February*, 1896.

[1] Quart. Journ. Geol. Soc., vol. xlii, p. 463.

THE NAMING OF NEW SPECIES.

Sir,—Has not Mr. Bather made a slip in the construction of the specific name for the new Crinoid described in your February Number? If he means to connect it with the county of Shropshire, as having been found on Salopian soil, surely the name should be *Merocrinus Salopicus*, just as we have *Megaceros Hibernicus*. *M. Salopiensis* would not, I think, be incorrect, but *M. Salopiæ* means that it is named after some fair nymph or lady of the name of Salopia.

I am glad that Mr. Bather preferred to associate the fossil with the district in which it was found rather than to pay its finder the doubtful compliment of naming it after him; and I would take the present opportunity of pointing out to those who feel compelled to associate a man's name with any new species they have to describe, that the adjectival form of a proper name is not only more correct, but is generally much more euphonious. Thus, if it is desired to commemorate someone of the name of Jones, *Jonesianus* is much better than *Jonesii*; and if the name were Bell, *Bellinus* would pass, while everyone would shrink from *Bellii* or *Belli*.

For my own part, I made a vow long ago that I would never attach a man's name to a new species, and I have kept it.

Teignmouth, *February 6th*, 1896. A. J. Jukes-Browne.

OBITUARY.

SEKIYA SEIKEI.

Born in 1855. Died January 9th, 1896.

All who are interested in volcanic and seismic phenomena will learn with regret that on January 9th, after an illness the first symptoms of which showed themselves in 1876, Professor S. Sekiya breathed his last. He was born in 1855, the year of the Ansei earthquake which devastated the Tokio plain. His attention was first directed to the serious study of earthquakes about 1880, and in 1886 he was appointed to the newly created Chair of Seismology in the Imperial University of Japan. Although he wrote much in Japanese, his publications in English, which for the most part appeared in the Science Journal of his own College and in the Transactions of the Seismological Society, in themselves testify to his industry and ability. The construction of a model to show the motion of an earth particle at the time of an earthquake is an indication of his originality and ingenuity. By his influence and persuasive power he did much towards the distribution of seismographs throughout his own country, and the extension of a seismic survey which at the time of his death boasted of no less than 968 stations at which earth shakings are recorded.

One thing in which he was interested, and in which he took part, were experiments to determine forms of construction most suitable for earthquake districts; and although he did not live to see the

ultimate results of these investigations, he saw that earthquake effects had already been diminished and that in future the loss of life and property would be further minimized.

His kindly disposition made him the friend of all who had the pleasure of his acquaintance, whilst the straightforward manner in which he never failed to express his ideas gained their admiration.

J. M.

MISCELLANEOUS.

A Glossary of the names of geological formations (*Piani e sotto-piani in Geologia*: Calabria, 1895) has been compiled by Signor U. Botti. It includes such terms as Albien, Algonkian, Sequanien, Toarcien, etc. In the preparation of his work the writer consulted a number of publications, but he seems mainly indebted to the "Tableau des terrains" of Mayer Eymar. We thus have a number of terms which have been formulated or modified by that particular author, but have never (or hardly ever) been used in geological literature: *e.g.* Bagshotin, Dartmouthian, Davidsin, (for St. David's beds—? meant for Davidsian), Llamberison (? Llanberisian), Llandeilian, Londinien, etc. We also make acquaintance with Anteparadoxidien, Bégudien, Boomin, Carcassien, Coutchiching, Dellysien, Devillien, Eobiotic, Falaisin, Frigidiano, Hydroplastic, Mibiélin, Nervien, Nicéen, Psychozoic, Etage de Sötern, Spanweton, Stampien, and Virgloriano—names which we give according to the spelling of Signor Botti. The work, though far from complete, will be useful to those who are perplexed about the meanings of some of the numerous terms of modern days: it will be useful also to those who are given to naming formations or groups of strata, as it may help them to avoid using a term already occupied. Thus we learn that the term Georgian (from Georgia) was introduced by Walcott in 1891, for the Lower Cambrian *Olenellus*-beds; but we may inform the writer of the Glossary that the term Georgian (from the districts bordering St. George's Channel) was suggested in 1885, by Dr. Hicks, for the rocks usually grouped as Cambrian.[1]

Svenska Växtvärldens Historia i korthet Framställd, af Gunnar Andersson. 8vo, pp. 106, 1 Map and 53 Figs. in the text. Stockholm: P. A. Norstedt and Sons.—Though this little book deals largely with the recent distribution of plants in Sweden, so much space is devoted to the past history of the flora, as preserved in peat-mosses, clays, and travertines, that it should not be overlooked by geologists. Dr. Andersson has done such excellent work in collecting and studying the fossil plants of Sweden, that we are glad to see his and Prof. Nathorst's leading results embodied in a truly scientific history of the origin of the Swedish flora. The author, being equally at home with the recent and fossil plants of Sweden, can trace the influence of bygone climatic changes, and can give interesting illustrations of the past and present distribution of certain of the species.

[1] Geol. Mag., Dec. III, Vol. II, p. 359.